Hearth Appliance Installations

Core Knowledge Reference Manual

FIRST EDITION

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NFI NATIONAL FIREPLACE INSTITUTE®
A CERTIFICATION AGENCY

Important! Please Read!

The NFI Certification Exams are based on the hearth industry's best practices. The primary resources for the exams are the Gas, Pellet , Woodburning or Hearth Design Specialist Hearth Systems Reference Manuals published by the Hearth, Patio & Barbecue Education Foundation. Some questions call for basic knowledge of home construction and general field experience, including interpretation and application of manufacturers' instructions. The NFI Certification exam is rather rigorous. It needs to be in order to maintain high industry standards and ensure quality certification for those who participate. This is NOT an open-book exam. Just a few words of advice: Read and study the manual!

While years of industry service provide an exceptional background prior to taking the NFI Certification exam, we have found that those who are most successful have taken the time to review the manual regardless of their years of industry experience. Review classes and other exam preparation training also positively support exam results, but they are most effective when combined with manual study. The review training does NOT guarantee success with the exam.

The exam is based on the following subjects:
I. Fundamental Knowledge (25% of the exam)

1. Combustion
2. Heat/Heat Protection
3. Safety Guidelines/Consequences of Actions
4. Construction Fundamentals

II. Installation Knowledge (75% of the exam)

5. Regulations and Instructions
6. Fuel Delivery (Gas only)
7. Appliance Requirements
8. Draft and Ventilation Principles
9. Venting Requirements
10. Post Installation Inspection and Service

For a complete Index of Knowledge Statements, please see the appendix in the back of your manual. For complete details about NFI policies and procedures, please refer to the NFI Policy Manual on the Industry Professional page at http://www.nficertified.org.

Standard calculators are permitted during the exam, however, *no other hand held devices (cell phones etc.) are allowed.*

We're looking forward to adding your name to the list of NFI Certified Professionals. If you have any questions, please feel free to contact me at 703-524-8030.

Rick Vlah

Rick Vlahos
Executive Director
National Fireplace Institute

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Helpful Hints for Taking the NFI Exam

Thank you for your interest in becoming certified through the National Fireplace Institute. Here are some helpful hints to assist you on your journey to becoming a NFI Certified Specialist.

- Study from the current NFI Reference Manual.
  - Each manual is specifically written to contain all the information that will be on the exam. The content is updated every three years. You may miss vital information if you study from an old manual.
  - Allow yourself a sufficient amount of time to study the manual before taking your exam. Field experience and educational classes may help you prepare for the exam, but nothing replaces the need to study the manual.
  - The 3-hour NFI Review class is often presented to help you prepare.
    - It is designed to REVIEW the material in the manual. This class will not teach you everything you need to know. It assumes you have already studied the manual.
    - The NFI Review class for each fuel type is now available online. For complete details call the NFI office.
- A Practice Exam is available for $19.95. It includes all three fuel types. The document will explain how we write the questions, why we write them that way, you'll have 10 sample questions for each fuel type, the right answer and why it is the right answer. To order, go to the NFI web site. It is available in a printed booklet or a PDF file.
- There are 67 multiple choice questions, you are allowed 90 minutes to complete the exam.
  - This is a closed-book exam.
- A Standard calculator is allowed but you may not use the calculator function on a smart phone. Cell phones or other handheld devices are not allowed.
- Bring a photo ID card with you to the testing location.
- If you have any questions, please do not hesitate to call.

If you have any questions, please do not hesitate to call.
Thank you,

Gwen Thompson

Gwen Thompson
Manager - Certification & Education Programs

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The tradition of a hearth appliance is deeply ingrained in American lifestyle and history. From colonial days, the hearth has always been a complex combination of a practical source of life sustaining heat and comfort, as well as an embodiment of style, charm, and romance. The modern hearth industry has been dedicated to delivering an array of products that fulfill the diverse objectives and tastes of homeowners.

Installation and Safety Standards

The installation portions of this study manual primarily cite NFPA 211: Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances, NFPA 54: National Fuel Gas Code, American National Standards Institute (ANSI) Standards and International Residential Code (IRC). The majority of state and local governing bodies have building codes that dictate rules for installation of hearth appliances. State and local codes are often developed from a model code. Normally, these codes have the force of law and should be strictly followed. It is important to note that this study guide is not intended to be used as a code or as a standard. In some cases, local codes will differ from the information included herein. Building officials often reference codes in citing requirements for the installation of hearth appliances. It is important for an installer to know which codes apply in the areas in which he or she is installing appliances. To find out which codes apply, it may be necessary to contact the local municipal, county, and/or state offices that have jurisdiction.

Purpose and Limitations

This manual has been prepared for informational purposes only and does not reflect the views of the Hearth, Patio & Barbecue Education Foundation (HPBEF) or the contributing agencies and companies, nor constitute an endorsement of any commercial product or person. Neither HPBEF nor its officers, employees, or agents makes any warranty with respect to this manual or assumes any liability arising from the use of this manual.

Obligations of Hearth Professionals

Sellers, installers, and service technicians of hearth appliances assume certain moral and legal responsibilities. The moral responsibility is clear. Improper installation or service potentially can lead to fires and other hazards resulting in loss of life and property.

Technicians and planners should also understand that legal action can arise from improperly installed and serviced appliances. If an incident occurs, all involved parties may be named in a lawsuit; this includes the manufacturer, the distributor, the retailer, the installer or service technician, the test laboratory, the building contractor, and subcontractor. All interests are best protected if everyone is uncompromisingly attentive to appropriate codes, understand and follow the manufacturer's installation and service instructions, and use the proper parts and materials.

Hearth, Patio and Barbecue Education Foundation (HPBEF)

The Hearth, Patio & Barbecue Education Foundation is a private, 501(c) (3) non-profit organization formed to serve the public interest by advancing the safe and responsible installation and use of hearth products. The Foundation promotes safety, understanding, and responsibility in all facets of hearth appliances and products through professional training, certification, and public education programs.

National Fireplace Institute (NFI)

The National Fireplace Institute® (NFI) is the professional certification division of the Hearth, Patio & Barbecue Education Foundation. NFI's objective is to increase public safety by establishing meaningful credentials for professionals involved in planning, installing and servicing residential hearth appliance and venting systems. NFI, established in 2002, certifies technicians and installers in four hearth product categories:

- NFI Gas Specialist
- NFI Woodburning Specialist
- NFI Pellet Specialist
- NFI Hearth Design Specialist

Since 1981, the Hearth, Patio & Barbecue Education Foundation® has conducted certification programs for the industry. In 2001, the move was made to update the certification program into one that meets the stringent national standards for certifying agencies. Doing so was a challenging and expensive process that included job analysis, exam blueprint and validation, and scoring methodology. The result however, has been a program that serves to greatly advance the credibility of the hearth industry and offer a basis for states and jurisdictions where licensing may be considered.

NFI recognizes individuals who have successfully gained all three fuel type NFI Certifications as **Master Hearth Professionals (MHP)**.

The NFI Hearth Design Specialist certification, the newest category created by the Hearth, Patio & Barbecue Education Foundation seeks to educate and certify those who are involved in the installation, planning and selling of hearth products of all fuel types.

How is the program governed?

NFI is ultimately governed by the Hearth, Patio & Barbecue Education Foundation (HPBEF) Board of Governors. However, numerous committees fulfill the crucial tasks of the ongoing development and maintenance requirements for each of the NFI certifications:

- **NFI Certification Committee:** Oversees and directs the various NFI sub-committees and reports directly to the HPBEF Board
- **Job Analysis Committee:** Composed of Subject Matter Experts (SMEs), this group surveys and identifies specific job tasks and required knowledge necessary for safe and correct installations
- **Manual Review Committee:** Using Job Analysis survey information, this group contributes, reviews, and edits the NFI Reference Manuals, the official study guides for the NFI exams
- **Exam Writing Committee:** Also using the data gathered by the Job Analysis survey process, they prepare exam questions under the guidance of a professional consultant
- **Cut-score Committee:** Using the Modified Angoff Procedure, this group reviews each exam question performance from a pilot over length exam to ultimately determine the passing score and eliminate poorly performing exam questions
- **CEU Committee:** The Continuing Education Unit (CEU) Committee is responsible for reviewing and accrediting educational sessions across the industry and makes policy recommendations on certification renewal to the Board

What is the value of having the credential?

The value of certification in any industry is well documented with positive implications in consumer satisfaction, employee retention, defined career paths, and job performance. NFI Certification provides value specific to the hearth industry in numerous ways, such as:

- NFI Certification increases public safety through the proper training and qualification of planners and installers
- Hearth manufacturers experience reduced callbacks and customer complaints due to faulty installations

- Hearth retail owners and managers can increase public awareness and consumers' confidence in their products and services
- Hearth professionals have a credible, nationally-recognized credentialing program through which they can validate their knowledge and advance in a career path

Thanks to these efforts, NFI is now recognized as the basis for licensure in several states, counties and local municipalities. Licensing is a local issue and many times NFI certification is required without any notice to the NFI office.

Who is eligible for the credential?

Anyone seeking a career path in the hearth industry is eligible and welcome to take an NFI exam. While there is no experience requirement for testing, NFI does recommend that anyone testing has at least two years of experience in the industry. NFI exams are offered by Hearth Patio & Barbecue Association (HPBA) regional affiliates, National Chimney Sweep Guild (NCSG) chapters, industry manufacturers and distributors, and specialty trainers. Exams are also offered throughout the year at PSI computer test facilities and from the comfort and convenience of your own home or office through an online exam program.

How is the credential earned and renewed?

NFI Certification is based upon the successful completion of one of the four NFI exams. Each NFI exam is a closed-book, multiple-choice exam based on the recognized knowledge for planning and installing appliances. To prepare, applicants must study the current edition of the Hearth Systems Reference manual(s). Due to the constant changes in the industry, the manuals and the exams are updated on a regular basis.

Each certification is valid for three years. A certification may be renewed by re-testing or by accumulating the appropriate number and category of continuing education units (CEUs), and paying a renewal fee. The requirements to renew a single certification by CEUs are 12 Technical CEUs, 4 Safety, Health & Liability (SHL) CEUs, and 8 Elective CEUs for a total of 24 CEUs. If a Specialist has two or three certifications, they are required to earn 16 Technical, 4 SHL, and 12 Elective CEUs for a total of 32 CEUs.

NFI Exam Development

The National Fireplace Institute® (NFI) certification exams were and continue to be developed through a process based on national testing standards that include a job analysis, exam blueprint, exam validation, and scoring methodology.

Job Analysis Study

The role of a hearth planner/installer in residential hearth product installations was carefully analyzed by Subject Matter Experts (SMEs) and hearth industry professionals who identified specific job tasks and areas of required knowledge necessary for safe and correct installations. Following the identification of job tasks and knowledge by SMEs, validation surveys based on the study were created and sent to over 8,000 hearth practitioners. The survey provided data that prioritized knowledge areas based on their relative importance to hearth products installation.

Development of an Exam Blueprints

The results of the industry survey provided a guide for determining exam content and appropriate percentages of questions in specific categories of job knowledge. An exam blueprint was developed for each certification.

Content and Exam Production

Specific questions relating to areas of performance, outlined in the job analysis study, were developed and written by industry subject matter experts who were trained by a consultant in exam question writing. Questions were then reviewed by the testing consultant for clarity and format and by industry experts for technical accuracy. Pilot exams with extra questions are administered. These over length exams allowed a final opportunity for review of every question.

Passing Score

Passing scores are determined through the modified Angoff Procedure, a nationally recognized method to set the score that distinguishes performance that indicates possession of knowledge needed for minimum competence. The process involves subject matter experts reviewing the relative difficulty of each question and the performance statistics from the pilot over length exam. The psychometrician then processes a statistical calculation to determine the passing score.

Credentialing and Recognition

Each certified hearth professional passing their respective NFI exam is acknowledged by a certificate, a photo I.D., and a listing on the NFI website, www.nficertified.org. The NFI website is used by consumers, builders, and building officials to identify certified hearth installers nationwide.

Summary

The need for a credible certification program can be summed up in two words: public safety. Hearth products, because they involve flame, heat and venting of combustion products, require specialized knowledge for planning and installing. The NFI exams are the only exams that test the knowledge needed to properly plan and install hearth products and their venting systems.

The importance placed upon NFI by the hearth industry has been the key to its success. With the implementation of the NFI Advocate program in 2003, many of the industry's largest manufacturers now recommend in their product operational manuals that their products be installed by NFI Certified Specialists. These credible, comprehensive certifications have successfully gained the recognition of building officials, legislative and regulatory agencies, and the general public.

Abbreviations

ASTM: American Society for Testing and Materials
HUD: US Department of Housing and Urban Development
IECC: International Energy Conservation Code
IFGC: International Fuel Gas Code
IGCC: International Green Construction Code
IMC: International Mechanical Code
IRC: International Residential Code
NFGC: National Fuel Gas Code
NFPA: National Fire Protection Association

Cited References

Since jurisdictions adopt versions of the codes on very different time schedules, we reference the latest edition of the code at the time of printing of this manual and the immediately previous one. The last two digits of the date indicate the year of publication of the code or standard: 99 is 1999; 09 is 2009.

Knowledge Statements

At the end of this manual is a list of knowledge statements that are related to the information covered in this manual. The list comes from Job Analysis of Hearth Installers/Planners. This study followed a formal process, including an industry wide survey, to identify the tasks that industry practitioners perform in their jobs and the knowledge needed to successfully carry out those tasks.

The purpose of the job analysis is to help focus on important knowledge and to ensure that certification exams accurately reflect the knowledge needed to perform the job of a hearth system planner or installer.

The Knowledge Statements indicate major references in this manual to each knowledge statement. The Index can be used to find and focus on a particular knowledge subject in the manual. It also will serve those who complete the certification exam in using the feedback report that identifies exam performance related to specific knowledge statements. In either case, it is important to understand that the referenced sections may be directly related to listed knowledge, or the information may be background material helpful in understanding concepts important to that aspect of job performance. In some cases, listed knowledge may be general in nature and therefore have broad coverage in the manual or they may be general knowledge expected as part of job experience.

It is important to note that this manual is not intended to be used as a code or standard.

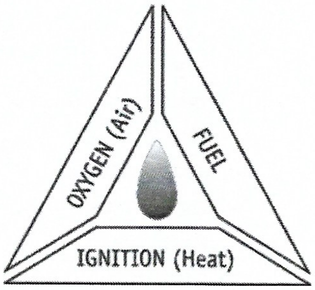
This manual is intended for instructional purposes only. It is not meant to replace the proper installation, operation, or service manuals for any appliance, component, or venting system. Many state or local governing bodies have building and mechanical codes that spell out mandatory rules for installation of hearth appliances and venting systems in the communities of their jurisdiction. Normally, these codes have the force of law, and they should be strictly followed. **In some cases, local codes will differ from the information in these study manuals.**

The majority of residential hearth appliances and venting systems are safety tested and listed by recognized testing laboratories. In some jurisdictions, only locally approved products may be installed. For all listed appliances, the installation instructions provide the necessary details for the safe installation and operation of the appliance. They must be adhered to unless local codes dictate otherwise.

In some jurisdictions, installation of a hearth appliance and venting systems requires a building permit. Where they are required, building permits should be obtained and the appropriate inspection conducted by the building inspectors. Some jurisdictions require that installation of hearth appliances and venting systems be performed only by an individual with an appropriate license issued by the city, state, or county building authority.

Chapter 1 Principles of Combustion

Combustion is a complex process. This fundamental knowledge is the basis for all sorts of decisions and information. Understanding the complex nature and requirements of combustion, however, is essential to knowing, troubleshooting, and explaining appliance operation and venting needs.

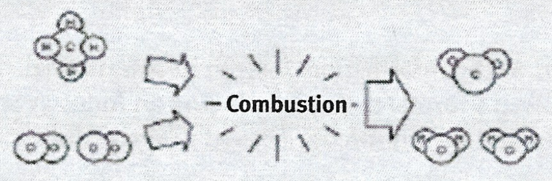


Combustion triangle

1.1 Combustion Requirements

Air, fuel, and heat must be present for combustion to occur. Hydrogen and carbon in the fuel mix with oxygen in the air, and the fuel is converted into heat, chemicals, and gases through the process of combustion. If any one of the three requirements – air, fuel or heat – is removed, combustion ceases. If all three are available in the proper amount, combustion is self-sustaining. Complete combustion produces water vapor, carbon dioxide, heat, and noncombustible ashes (in solid fuel appliances). Incomplete combustion produces carbon monoxide, hydrocarbons, and other gases, as well as water and noncombustible ashes. The rate at which a fuel burns is, broadly speaking, controlled by the amount of available air. The air-to-fuel ratio is a critical factor in obtaining optimum fuel combustion. Insufficient air, or oxygen, results in excessive unburned gases and combustion may cease completely. Too much air will cool the fire and again result in incomplete combustion or extinguish the fire. Significant differences in appliance technologies call for more thorough understanding of appliance operational needs than in the past.

Combustion of methane and oxygen



Fuels differ in energy content. Energy content is a measure of the available chemical energy per pound of wood or cubic foot of gas of fuel. It is normally expressed in British Thermal Units (BTUs). Compared to energy content, heating value is the amount of heat actually available from a fuel (also expressed in BTUs). A fuel's actual heating value is directly related to its energy content, but is also affected by other variable factors such as moisture content in wood. Table 1 shows relative heating values for several common fuels.

1.1.1 Steps in Combustion

In a simplified combustion process, the following steps occur:

- Hydrogen and carbon atoms of the fuel come in contact with oxygen atoms.
- Heat is introduced to the mixture increasing the molecular speed of the gas and oxygen molecules.
- This high speed causes the molecules to collide with enough energy to break old bonds and form new ones. As this happens, the molecules release additional heat. This results in self-sustained combustion.

The new products which are produced are carbon dioxide ($CO2$) and water vapor ($H2O$).

Controlled and uncontrolled combustion

Controlled combustion	Explosion
Proper air-to-fuel ratio	Improper air-to-fuel ratio
Complete burning	Complete burning
Steady flame	Steady flame

Controlled combustion occurs when fuel and air are supplied at a proper rate; this assures complete burning in a steady flame. Explosion, on the other hand, is rapid burning with an improper supply of air and fuel; it is not under control, and excessive pressure builds up.

1.1.2 Stages of Wood Combustion

Solid fuel (wood and wood pellet) combustion is a complex physical-chemical process during which hydrogen and carbon in the fuel are chemically combined with oxygen to form combustion products and to release heat. Once air and fuel are present, heat must be applied to initiate the combustion process. High temperatures result in higher molecular speed, allowing the fuel's molecules to collide with sufficient energy to break old bonds and form new ones; these "reactions" release additional heat. The continued presence of sufficiently high temperatures results in self-sustained combustion.

Solid fuel combustion can be divided into four identifiable stages. These stages occur consecutively in a given piece of wood, but in the burning conditions of a fire chamber the stages occur simultaneously.

Stage I: Moisture Evaporation. When wood is heated, moisture evaporates to form steam. As moisture evaporation occurs, heat is absorbed, not given off. High moisture content in firewood requires more heat to boil the water off. The result is difficulty starting the fire, delay in moving the combustion process to the next stage, and the loss of available heat from the fuel.

Stage II: Vaporization of Hydrocarbon Compounds. As temperatures rise, the chemical structure of the wood molecules begins to break down, and hydrocarbons begin to vaporize. These chemical changes caused by heat are known as pyrolysis. Pyrolysis produces a complex mixture of hydrocarbons in the form of liquid tar droplets and combustible gases. As pyrolysis begins, none of the hydrocarbon vapors will burn. Heat is still being absorbed, not given off. As temperatures increase, some of the gases, such as methane, begin to ignite under optimum conditions. Small amounts of additional water vapor, carbon dioxide, carbon monoxide, and combustible and noncombustible vapors are released.

Stage III: Gas Vapor Ignition and Combustion. The hydrocarbon gases and tar droplets, referred to here as gases, will ignite if they reach a threshold temperature in the presence of oxygen. Between 540°F and 1,225° F, the gases will ignite if adequate oxygen is available. Carbon will react first with oxygen to produce carbon monoxide, a combustible gas. If sufficient oxygen is present, the carbon monoxide will then react with oxygen to produce carbon dioxide. More than half of the available heat in wood comes from the burning of gaseous hydrocarbons and carbon monoxide. Thorough combustion thus depends on combustible gases remaining in the combustion chamber long enough to reach ignition temperatures generally over 1,100° F. Moisture from inadequately seasoned firewood slows down or prevents reaching high ignition temperatures, resulting in reduced efficiency and increased products of incomplete combustion. Excessively dry wood, however, can also result in higher emissions due to its tendency to evolve and release gases at a rate that outstrips the appliance's ability to supply adequate combustion air. As gases burn, internal firebox temperatures can reach up to 2,000°F.

Stage IV: Char Burning. Charred wood must come into direct contact with oxygen before it will burn. This occurs only after moisture evaporation, pyrolysis and the release of gases have subsided (above approximately 950° F). Basically, the carbon in the charcoal is the only remaining combustible material. Charcoal burns with little or no flame, producing temperatures in excess of 1,100° F.

1.2 Complete Combustion

1.2.1 Heat

Fuel is ignited by heat, not necessarily with flame present. Wood ignites at about 450° – 550° F, natural gas ignites at about 1,150° F and propane gas ignites between 920 – 1,120°F.

Heat Sources and Temperatures

- Electric spark (blue as with piezo spark) - 1,700°F
- Hot surface igniter - 2,400°F
- Stick match - 3,000°F
- Butane lighter - 3,200°F
- Cigarette - 600-800°F

Table 1: Heating values of common fuels

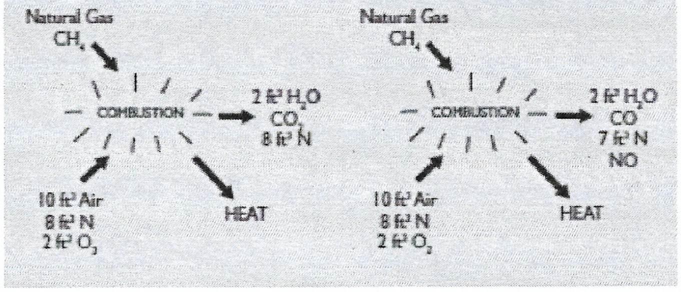
BTU per pound

Wood (50% moisture)	Approximately 4,000
Wood (20% moisture)	Approximately 6,200
Wood (oven dry)	Approximately 8,600
Coal	11,000—14,000
#2 fuel oil	19,750
Gasoline	20,700
Natural gas	22,800

1.2.2 Air

The oxygen necessary for combustion comes from the air surrounding the appliance or from an inlet connected to the outdoors. Air contains approximately 20% oxygen and 80% nitrogen. Therefore, we also introduce nitrogen into the combustion process. Because nitrogen does not combine with any of the other elements, it is unaffected by combustion, and it appears in the combustion products unreacted. Complete combustion is possible only with an adequate supply of oxygen.

Complete (left) and incomplete combustion



1.2.3 Fuel

For complete combustion, two molecules of oxygen need to be mixed with one molecule of fuel in the presence of heat. When this happens, heat, carbon dioxide (CO2), water vapor (H2O) and nitrogen (N) are released.

1.3 Incomplete Combustion

Efficiency in a stove or fireplace is important not only in terms of economy and heat production, but also because of pollutants and potential fire hazards produced when combustion is incomplete.

Incomplete combustion can be a result of inadequate amounts of oxygen in the air-to-fuel mixture. Conditions that can result in unwanted incomplete combustion include (individually or in combination):

- Inadequate combustion air or due to blockage of air openings resulting from poor maintenance.
- Cooling of the flame by a poorly built fire in a woodburning appliance or flames improperly contacting logs in a gas appliance (flame impingement).
- Inadequate introduction of secondary air due to poor venting in a gas appliance. Inadequate draft does not bring enough secondary air to the flame needed to complete combustion in a woodburning appliance.

1.3.1 Carbon Monoxide

A highly toxic gas, carbon monoxide is odorless, colorless, tasteless, and combustible at high temperatures. Carbon monoxide (CO) is a product of incomplete combustion. Under normal circumstances, CO produced in incomplete combustion exits the venting system. With flue blockage or other problems, this product of incomplete combustion might spill into the house.

Carbon monoxide is a dangerous and highly toxic gas because it mixes with blood and reduces oxygen carrying capacity; 200 parts of CO in a million parts of air (ppm) can cause slight headaches, fatigue, and dizziness. Individual reaction may vary among people due to weight, age, smoker, and other factors, but it is well documented that very small amounts are dangerous.

Effects of low level exposure over time are cumulative and can include organ and brain damage. Infants, elderly, and the infirm are more susceptible to the toxic effects. Symptoms of CO poisoning include flu-like symptoms, nausea, chronic fatigue, and generalized depression. CO poisoning can be diagnosed through a blood test and treated. High levels of CO poisoning can lead to collapse and death.

Facts about carbon monoxide (CO)

When inhaled and introduced into the bloodstream through the lungs, the protein hemoglobin in the blood combines much more readily with CO than with oxygen (at a rate of 300:1). The replacement of oxygen with CO in blood results in varying degrees of cell suffocation, depending on the intensity and duration of exposure. Muscles and organs are deprived of the oxygen needed to sustain them.

The harmful effects of exposure to CO depend on:

- CO concentration
- Length of exposure to CO
- Health, age, sex, and size of individual exposed.

1.3.2 Aldehydes

Aldehydes, chemical compounds that have a strong pungent odor, are produced in incomplete or interrupted combustion. Aldehydes result from flame impingement and through the presence of contaminated air in the combustion system. Lint, dust, hair, and the like contaminate the air supply and call for complete cleaning service.

When the pungent odor of aldehydes is present, carbon monoxide is also present. It is important to note, however, that odorless (and undetectable by smell) carbon monoxide can be present without the presence of detectable or noticeable aldehydes.

Chapter 2 Efficiency

When the requirements of fuel, air, and heat are met and combustion occurs, the next concern is how completely the fuel burns and how much of the heat produced is delivered to the home. That concern is broadly known as efficiency, but that term includes various types of efficiency (combustion, heat transfer, and overall efficiency). In its simplest terms, efficiency is defined as Heat Output divided by Heat Input.

2.1 Factors Affecting Efficiency

The factors affecting combustion efficiency are factors that influence one or more of the "three T's" – temperature, turbulence, and time. The same factors also influence heat transfer efficiency. When combustion and/or heat transfer efficiency are influenced, overall energy efficiency is affected.

2.1.1 Temperature

Every combustible substance has a minimum ignition temperature that must be maintained if combustion is to start and continue. High temperatures are essential to combustion efficiency because of the ignition temperature requirements from the large percentage of available heat in the otherwise unburned gases.

2.1.2 Turbulence

Fuel molecules must collide with oxygen molecules for combustion to occur. Turbulence refers to the degree of fuel and air mixing that occurs in the combustion zone and is an important factor in combustion efficiency.

2.1.3 Time

"Time" refers to the amount of time fuel gases remain in the high temperature combustion zone and is known in the industry as residence time. Since the chemical reactions of combustion proceed at different rates for different gases, sufficient residence time must exist for the combustion reaction to be completed. And the flame must avoid contact with cooler surfaces whose lower temperatures impede combustion. Inadequate residence time adversely affects combustion efficiency. As 100% combustion efficiency is approached, the only byproducts of combustion are water vapor, carbon dioxide, and noncombustible ashes. Although complete combustion or high combustion efficiency may be desirable, in reality, combustion is often incomplete.

2.2 Heat Transfer Efficiency

Combustion efficiency, or the percentage of the fuel's energy that is converted to heat, is only half of the overall energy efficiency equation. The other half is heat transfer efficiency. Heat transfer efficiency refers to the percentage of heat generated by combustion actually transferred to the interior space or room. It is possible to have high combustion efficiency and low heat transfer efficiency, or low combustion efficiency and high heat transfer efficiency. Heat transfer efficiency is primarily an issue with free standing stoves, since fireplaces are usually considered for recreational and aesthetic purposes. High heat transfer efficiency is normally associated with:

- The appliance having proportionately large exterior surfaces with good heat radiating properties.
- Long residence time of the hot gases in the appliance.
- Adequate turbulence inside the appliance to properly transfer heat from the fire chamber to appliance walls.
- Rapid heat transfer through the walls of the appliance.
- Adequate air movement (convection) outside the appliance to properly transfer heat away from the appliance.

Heat transfer efficiency is an important component in overall energy efficiency. Very high combustion efficiencies are desirable and achievable. The desirability of complete heat transfer efficiencies, however, is limited by practical considerations. If all, or most, of the available heat was transferred from the appliance to the room, draft and water condensation problems would result from the extremely low stack temperatures.

Neither fireplaces nor free standing stoves will perform properly if the venting system for it is too short or has too many bends or long horizontal runs. Venting systems must be sized carefully. Appliances and their vents must be thought of as a matched and complete system. This is particularly true with today's high efficiency units. Chimney sizing is critical to these draft sensitive units that deliver more heat to the living area of the home and less to the chimney.

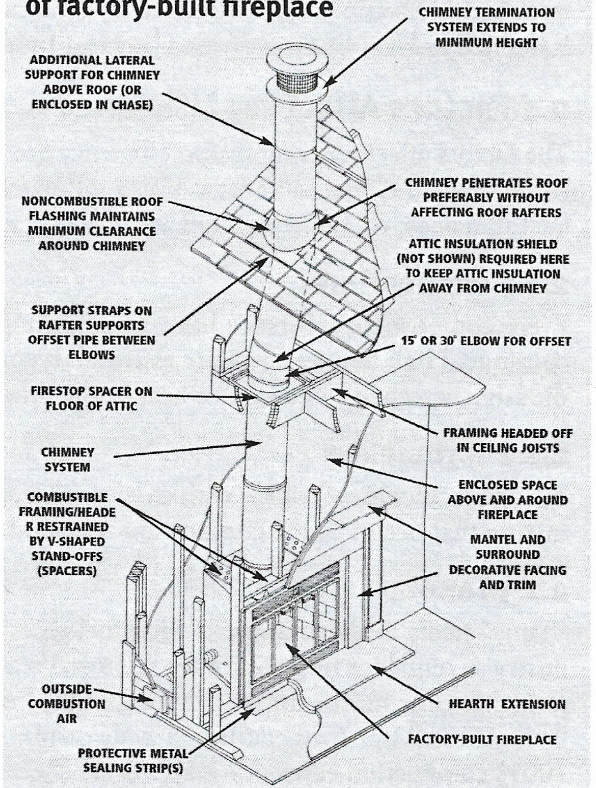
3.1 Factory-Built Fireplaces

From the consumer's point of view, a factory-built fireplace is a versatile and economical way to enjoy the warmth and beauty of an open fire. To the fireplace planner and installer, the factory-built fireplace is a tested system that includes a metal firebox, a venting system, and various components and accessories. A characteristic that distinguishes factory-built fireplaces from other hearth products is the production, testing, and listing of all major components from one manufacturing source. Other products such as free standing stoves and built-in high efficiency fireplaces have designated venting systems which may be produced by independent sources. Installers can choose from a number of approved sources for those appliances, but with open chamber factory-built fireplaces, the chimney is an integral, required component of the overall fireplace system.

The concept of the system cannot be overemphasized. Proper performance and safety depend on assembling and installing all necessary system components as detailed in manufacturer's instructions and avoiding using or substituting nonsystem components. Aftermarket fireplace doors designed and listed for masonry fireplaces are common nonsystem components that can have serious effects on the ability of the factory-built fireplace to cool itself. As such, they constitute a serious fire hazard.

There are essentially two types of factory-built fireplace designs – radiating and circulating – and they come in many shapes, sizes and styles.

Typical residential installation of factory-built fireplace


CHIMNEY TERMINATION SYSTEM EXTENDS TO MINIMUM HEIGHT
ADDITIONAL LATERAL SUPPORT FOR CHIMNEY ABOVE ROOF (OR ENCLOSED IN CHASE)
CHIMNEY PENETRATES ROOF PREFERABLY WITHOUT AFFECTING ROOF RAFTERS
NONCOMBUSTIBLE ROOF FLASHING MAINTAINS MINIMUM CLEARANCE AROUND CHIMNEY
ATTIC INSULATION SHIELD (NOT SHOWN) REQUIRED HERE TO KEEP ATTIC INSULATION AWAY FROM CHIMNEY
SUPPORT STRAPS ON RAFTER SUPPORTS OFFSET PIPE BETWEEN ELBOWS
15° OR 30° ELBOW FOR OFFSET
FIRESTOP SPACER ON FLOOR OF ATTIC
FRAMING HEADED OFF IN CEILING JOISTS
CHIMNEY SYSTEM
ENCLOSED SPACE ABOVE AND AROUND FIREPLACE
COMBUSTIBLE FRAMING/HEADER RESTRAINED BY V-SHAPED STAND-OFFS (SPACERS)
MANTEL AND SURROUND DECORATIVE FACING AND TRIM
OUTSIDE COMBUSTION AIR
HEARTH EXTENSION
FACTORY-BUILT FIREPLACE
PROTECTIVE METAL SEALING STRIP(S)

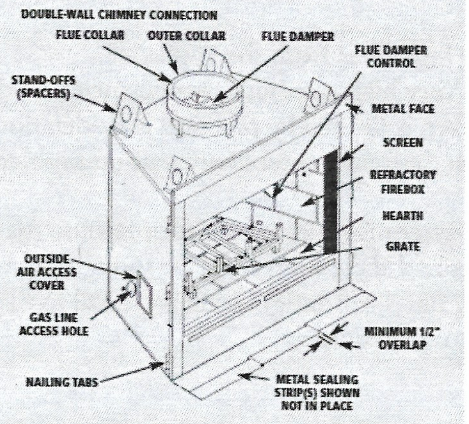
3.1.1 Radiant Design

The radiant design system transmits heat energy from the firebox opening by direct radiation to the space in front of it. Radiant factory-built fireplaces usually do not have grilles or louvers on the face of the fireplace. Heat moving blowers are not available.

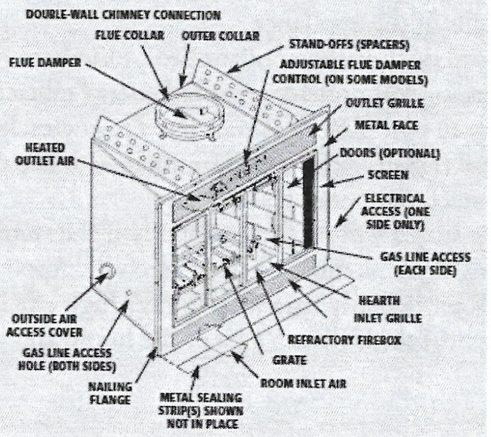
3.1.2 Circulating Design

The circulating design system adds the function of heat transfer via heated air convection by circulating air around the fire chamber and releasing it to the space to be heated through grilles and louvers. Intake air is generally located below the firebox or low on the sides adjacent to the opening, and the heated air exhausts through grilles or louvers located above the firebox or high on the sides adjacent to it. Some systems employ ducts to circulate heated air to spaces other than the area of the front of the fireplace. Some circulating systems rely on natural convection while others have electric blowers to move the air. Depending upon the design, these blowers may be either required or optional.

Typical factory-built fireplace: radiant type

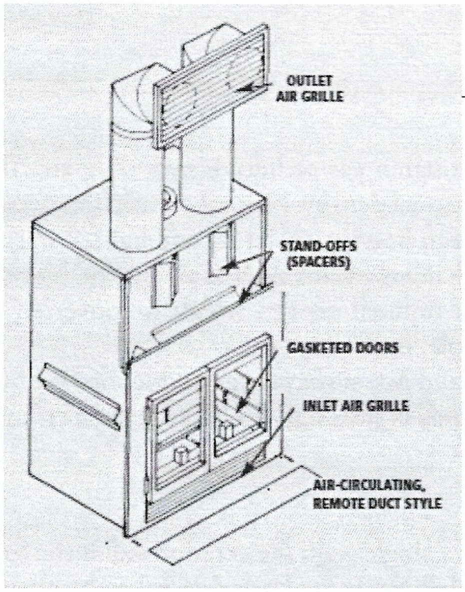


Typical factory-built fireplace: circulating type


DOUBLE-WALL CHIMNEY CONNECTION
FLUE COLLAR
OUTER COLLAR
STAND-OFFS (SPACERS)
FLUE DAMPER
ADJUSTABLE FLUE DAMPER CONTROL (ON SOME MODELS)
OUTLET GRILLE
METAL FACE
HEATED OUTLET AIR
DOORS (OPTIONAL)
SCREEN
ELECTRICAL ACCESS (ONE SIDE ONLY)
GAS LINE ACCESS (EACH SIDE)
HEARTH
INLET GRILLE
OUTSIDE AIR ACCESS COVER
REFRACTORY FIREBOX
GAS LINE ACCESS HOLE (BOTH SIDES)
GRATE
NAILING FLANGE
ROOM INLET AIR
METAL SEALING STRIP(S) SHOWN NOT IN PLACE

3.1.2.1 Fireplace Design and Appearance

Factory-built fireplaces are typically open front designs, but corner opening, three sided units with openings either on the front or side, four-sided units, and see-through opening systems are available as well. The inside walls of the firebox may be exposed sheet metal, or there may be refractory panels imitating the look of firebrick lining the firebox.



An attempt to make masonry fireplaces more efficient was with the use of a steel firebox with a damper surrounded by an air chamber and second steel wall, enclosed in at least 8 inches of solid masonry were very popular from 1960-1980 as they eliminated the need for a trained mason to build sloping firebox walls. However, home owners often confuse these fireplaces with factory-built fireplaces. Some popular brands were Heatilator and Superior. Superior had a model called the Heatform®, which along with Heatilator became generic terms used to describe metal fireboxes in masonry fireplaces. However, there were also other manufacturers of these units.

3.2 Built-in, High Efficiency Fireplaces

Built-in appliances (also known in the industry as hybrid or high efficiency fireplaces) contain efficient combustion and convection chambers that are enclosed in an insulated metal cabinet designed like factory-built open fireplaces. These metal cabinets containing the appliance can be enclosed in close proximity to combustibles. This allows a facing such as masonry or ceramic tile to give the appearance of a fireplace without the expense of the full masonry fireplace, chimney, and insert. The venting system is a specified factory-built chimney.

These built-in heaters may operate as room heaters do, delivering radiant and forced air heat to the space in which they are located. Some, however, offer the option of forced air and/or gravity ducting of heat to other areas of the home.

3.3 Free Standing Room Heaters

Free standing room heaters include appliances located in the living area of the home and which deliver heat directly to the space in which they are located. They are not designed to accept ducts and/or pipes for heat distribution to other parts of the home.

3.4 Fireplace Inserts and Hearth Stoves

Fireplace inserts and hearth stoves are appliances designed to improve the efficiency of an open fireplace. Fireplace inserts are installed in open fireplaces with metal panels or shrouds. Typically a liner will be installed to properly vent the insert and prevent room air from interacting with flue gases. Fireplace inserts retain the general appearance of the fireplace while dramatically improving its efficiency.

3.5 Hearth Appliance Construction

Modern solid fuel appliances are designed to introduce combustion air through specific and controllable air inlets. The air supply, and therefore the combustion rate, is controlled by the user. Although wood burning appliances have been commonly described as "airtight," no appliance is completely airtight. A more accurate term is "controlled combustion." Most controlled combustion devices are constructed of cast iron or steel, or a combination of the two metals. Although the thermal conductivity (heat transfer) properties are very similar, there are other differences in these materials.

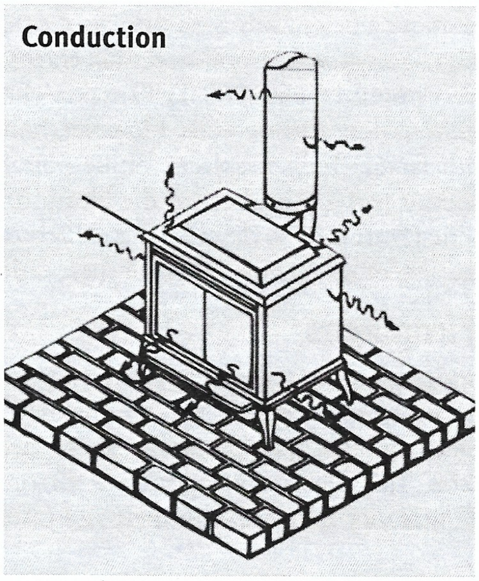
Cast iron, because it is poured into molds, can add decorative features such as arches, curves, scrolls, and relief work unattainable with steel. The parts of cast iron appliances are put together in tight fitting joints that are sealed with furnace cement and/or gasketing. The life span of furnace cement is such that eventually these appliances have to be serviced by taking the appliance apart, cleaning joints, and resealing with furnace cement. Steel appliances, on the other hand, have welded joints that need no service. Some appliances use steel fireboxes inside decorative cast iron outer cabinets.

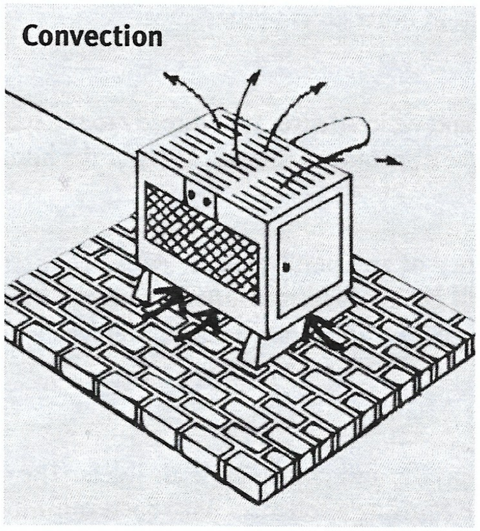
Some appliances are also constructed using soapstone, a material with lower thermal conductivity properties than cast iron or steel, but with greater specific heat (the amount of heat that can be stored in a given amount of weight). In other words, these appliances deliver heat more slowly than metal appliances, but retain and deliver heat longer. This characteristic can be an advantage or disadvantage depending on climate, operating skills, and other factors.

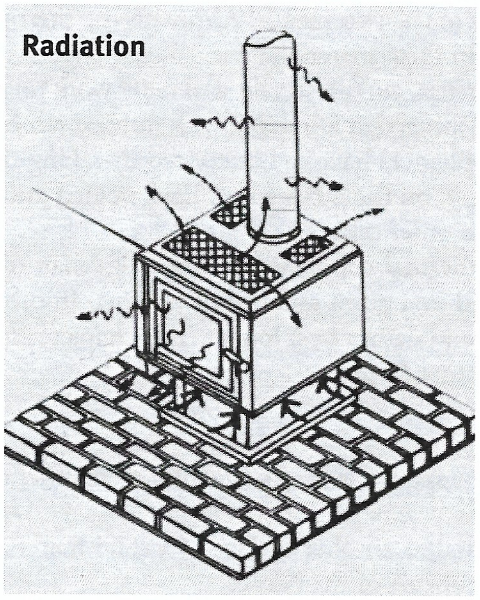
3.6 Heat Delivery

Hearth appliances can be further classified according to the way they heat interior spaces. It may be helpful to first define methods of heat transmission:

Conduction: the direct transmission of heat from one surface of a solid material to another surface of a solid material. Obviously direct contact with hot surfaces, or conduction, is to be avoided by occupants of the home.


Conduction


Convection


Radiation

Convection: the transfer of heat through a gas or liquid, including air. The transfer of heated air between areas of unequal density. Natural convection occurs because of temperature differences between heavier, cooler air and lighter, warmer air. Forced convection occurs by mechanical means such as an electric blower.

Radiation: the emission of waves of infrared energy, which is converted to heat on contact with solid surfaces (people, furniture, walls).

Since direct contact between people and hot surfaces, or conduction, is obviously to be avoided, the applicable methods of heat transfer here are radiant, convection, and a combination of the two.

3.6.1 Radiant Appliances

Radiant appliances are constructed with a single wall; the exterior wall is the firebox wall. The primary method of heat delivery is the heated metal transmitting waves of infrared energy in all directions. Like the radiant energy of the sun, the radiation from the appliance changes to heat on contact with solid surfaces primarily. Also like the sun's energy, the intensity of the absorbed heat is a matter of both distance and geometry. The farther away from the energy source, the less available energy. Less obviously, the direction, or angle, between the source and the absorbing surface affects heat absorption and perception. Because of these qualities, radiant appliances are generally recommended as more effective for large open areas than for configurations of numerous smaller rooms.

3.6.2 Convection Appliances

Convection appliances use double wall construction. An air space between the firebox wall and the second or cabinet wall, open at the top and bottom, allows room air to circulate. As the air passing through the airspace absorbs heat from the firebox wall, it becomes lighter and more buoyant and draws cooler air from the bottom as it exits at the top. In turn, this heated air travels away from the appliance, gradually cools, falls, and returns slowly back to the appliance in what is known as convection currents.

Convection appliances may or may not have a blower to increase the amount and distance of heated air circulation. A secondary benefit of this design is lower surface temperatures of the outer wall exposed to the room.

Often known in the past as "circulating heaters," convection appliances are often recommended for less open space configurations. It should be noted, however, that delivering convected heat long distances may mean uncomfortably warm or stuffy temperatures in the area immediate to the appliance.

3.6.3 Combination Appliances

A third type of appliance is a combination radiant/convection heater. The second wall convection cabinet is present but does not completely surround the firebox. The loading door, usually with glass in new appliances, and possibly other firebox wall surfaces are exposed to the room. The cabinet delivers heated air gradually by convection currents while the exposed metal and glass transmit radiant energy waves. Optional blowers are available. The advantage of this combination is the more even distribution of heat due to the delivery of radiant energy in the immediate area of the appliance. Since this energy primarily heats objects and does not increase air temperatures significantly, the difference between immediate and distant room temperatures is reduced.

Chapter 4 Codes & Standards for Hearth Appliances

Hearth appliances are subject to safety testing and installation requirements that help protect the public. Although the two parts of this network are developed separately, they are applied together to ensure that hearth systems offer maximum safety and reliability.

Many state and local governing bodies have building codes that spell out mandatory rules for installation of hearth appliances. Some adopt or adapt consensus standards as part of their codes. Normally, these codes have the force of law and should be strictly followed. State and local codes are often developed from model codes and standards. The major code groups and mandatory codes/standards that apply to solid fuel appliances include:

- Underwriters Laboratories (UL)
- National Fire Protection Association (NFPA)
- International Code Conference (ICC)
- American Society for Testing and Materials (ASTM)
- American National Standards Institute (ANSI)

4.1 Product Standards System

Standards are specifications that a product manufacturer must follow and have verified by independent testing. The specifications in standards range from tested appliance and venting performance and safety to strength of materials used in manufacturing. The hearth industry standards are developed by organizations such as Underwriters Laboratories (UL) and American Society for Testing and Materials (ASTM). Manufacturers choose the appropriate standards for testing their products based on the product design and intended use.

Standardization began in the early twentieth century with gas utility companies providing specifications for gas range manufacturers. In 1918, the American Gas Association (AGA) was formed and consolidated the preparation of appliance standards in the U.S. AGA established testing laboratories to assure appliance conformity to standards, and in 1930 the Z21 Committee of the American Standards Association, now American National Standards Institute (ANSI), was established. The Canadian Standards Association (CSA) was chartered in 1919 and accredited to the National Standards system in 1973.

In the 1990's ANSI and CSA began a process of harmonization, or coordination of gas appliance standards so that requirements for manufacturing and testing become more consistent in the U.S. and Canada. Standards for both organizations are awarded by International Approval Services (IAS), now a subsidiary of the principle certification and standards administration agency, CSA International. ANSI and Canadian Gas Association (CGA) are the primary sources of standards for the fuel gas industry in North America administered by CSA. Representatives from gas utilities, appliance manufacturers, government agencies, and other interested parties make up subcommittees that establish, revise, and update numerous gas appliance (hearth and other) standards.

The process of developing standards, however, is for good reasons a deliberate and fairly slow process. The early approach to providing standards for the rapidly developing new gas hearth products was adaptation of existing blue flame standards. The result was, on one hand, a reasonably smooth process that allowed for the production of safety-tested appliances. On the other hand, manufacturers chose to test and list products to a confusing array of different standards.

Through negotiation and deliberation over the years, the process of harmonization has resulted in a more understandable and appropriate set of standards for yellow flame hearth appliances. Reviewing those changes can reduce confusion about standards, including their terminology and requirements.

Code and standards definitions

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Approved. Approved products are acceptable to the "authority having jurisdiction."

Labeled. Equipment or materials to which have been attached a label, symbol, or other identifying mark of an organization which is acceptable to the "authority having jurisdiction" which maintains periodic inspection of the production of labeled equipment or materials, and by whose labeling the manufacturer shows compliance with appropriate standards or performance.

Listed. Equipment or materials tested to required standards by a testing organization acceptable to the "authority having jurisdiction;" may be included in a list published by a model code organization acceptable to the "authority having jurisdiction." Both organizations maintain periodic inspection of production of listed equipment or materials state that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

4.1.1 Product Testing

A manufacturer must take extensive steps to obtain a safety listing for a hearth appliance. A prototype is constructed and tested by the manufacturer, using the relevant standard as a guide. Often, many design changes occur before the product is eventually submitted for performance testing to an independent testing laboratory. When the manufacturer is satisfied that the product will meet the requirements, arrangements are made for testing the product by representatives of a testing laboratory. This involves a review of the manufacturer's installation instructions and an examination of the prototype to assure conformance with the construction and materials requirements of the standard. This is followed by an exhaustive series of fire and strength tests. It is important to note that if the product meets the requirements specified in the standard, it does so using only parts specified by the manufacturer. Therefore, substitution of parts produced by another manufacturer may not yield the same results. This is why substitution of parts in the field, which are not specified for use, may create a hazardous situation. And regardless of performance of substituted parts, they void most manufacturers' warranties and open the door for liability actions.

4.1.2 Product Listing

If the product meets all of the requirements, the manufacturer is authorized to apply listing marks to all those products that are the same as the test sample. After production of the newly listed product begins, the manufacturer must continue to construct that product in the same fashion and be open for nonscheduled periodic inspections made by the testing/listing agency to assure that the product models are being built in accordance with the agreements.

4.1.2.1 Masonry Chimneys

Although materials used in constructing masonry chimneys (such as flue liners and mortar) are subject to product standards, the chimney, as a site built and essentially custom made system, is not subject to testing. Construction standards for masonry chimneys are included in the National Fire Protection Association (NFPA) Standard 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances and in the International Residential Code.

4.1.2.2 Product Labeling

Each listed appliance or factory-built chimney must be labeled in accordance with the requirements in the relevant standard. This includes marking of the appliance with manufacturer's name or symbol, the distinctive type or model designation, and the date of manufacture. The electrical rating of the blower, if installed, may be either on the appliance or the blower. Other safety information and warnings may appear on a place visible to the user. Airspace clearance requirements appear on the exterior of the firebox and on chimney sections. Each individual part of a factory-built chimney system, such as a chimney section, firestop, radiation shield, or a roof housing is marked with the manufacturer's name or identifying symbol and the distinctive type or model designation.

4.2 Standards for Hearth Industry Products

Underwriters Laboratories, Inc. (UL) is recognized as a leader in developing safety standards. UL provides safety related certification, validation, testing, inspection, auditing, advising and training services to a wide range of clients, including those in the Hearth industry. There are also many independent labs that test to the UL standards.

4.2.1 UL127 Standard for Factory-Built Fireplaces

UL publishes the safety standard UL 127, Factory-built Fireplaces. The requirements contained in this standard cover solid fuel (wood or coal burning) factory-built fireplaces.

UL 127 listed fireplaces include both fireplaces intended for decorative purposes and higher efficiency units. UL 127 fireplaces that are to be approved for use with listed unvented gas log sets must be tested and listed for such use or indicate that unvented gas log sets are not to be installed in them.

Chimneys for these fireplaces comply with either a 1,700°F flue gas temperature test or with a 2,100°F test, at the manufacturer's option. Approved chimney models and components are specifically indicated by the appliance manufacturer.

4.2.2 UL1482 Standard for Solid-Fuel Type Room Heaters

Appliances tested to UL1482 include freestanding stoves, fireplace inserts, and some built-in high efficiency fireplaces. Solid fuel room heaters are vented with either a residential masonry chimney or a factory-built chimney tested to 2,100°F (UL 103 Type HT).

These appliances are also known as controlled combustion appliances, which refers to the capability of the operator regulating combustion air intake. These appliances are designed with tight fitting, gasketed doors that are closed during operation. Combustion air enters only through operator adjusted air inlets. That capability results in high efficiency, regulated heat output, and extended burns that are not possible from the open combustion chamber of a fireplace.

4.2.3 UL103 Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances

Factory-built chimneys approved for use with woodstoves and some factory-built fireplaces are covered in UL 103 Factory-built Chimneys for Residential Type and Building Heating Appliance. UL 103 subjects chimneys to a sustained 1,000°F test and then to a ten minute higher temperature test, either to 1,700°F or to 2,100°F. The 2,100° test is known as the high temperature or HT test. Chimneys that are tested to 2100° F, rather than 1700° F, receive a UL 103-HT listing. The manufacturer can choose either testing method.

4.2.4 UL641 Standard for Type-L Low Temperature Venting Systems

This standard, originally covering factory-built vent piping and fittings for use with gas and oil appliances, has been the basis for testing pellet venting products. Testing agencies conduct applicable test procedures and follow some additional requirements for pellet products.

Temperature tests are an important part of the procedure. Two tests are conducted: Temperature Test - 570°F (299°C) Flue Gases, and Temperature Test - 1,700°F (927°C) Flue Gases.

4.2.5 UL1618 Standard for Wall Protectors, Floor Protectors, and Hearth Extensions.

These requirements cover wall protectors, floor protectors, and hearth extensions intended for use with heat producing devices, such as fireplaces, fireplace stoves, fireplace inserts, and solid-fuel type room heaters. A floor protector is defined in the UL 1618 standard as noncombustible surfacing applied to the floor area underneath and extending in front, to the sides, and to the rear of a heat producing appliance. And hearth extensions are defined as noncombustible surfacing applied to the floor area extending in front of and at the sides of the hearth opening of a fireplace or fireplace insert. Since 2015, the International Residential Code (IRC) requires that listed and labeled hearth extensions must comply with UL 1618.

Woodstove manufacturers may test either without or with thermal protection. If the appliance is tested without thermal protection, the installation instructions only have to indicate the minimum extension dimensions beyond the loading or ash drawer openings, the sides and back of the appliance. Installation instructions for stoves tested with thermal protection must include the minimum extension measurements beyond the appliance doors, sides, back, horizontal connector width and the thermal protection information.

4.2.5.1 Floor Protection

The two categories of floor protectors are:

Type 1 Ember Protector for appliances that do not require thermal protection of the combustible floor during normal operation. Installation instructions for these appliances indicate dimensions, but no thermal requirements for floor protection.

Type 2 Thermal Floor Protector for appliances requiring thermal protection of the combustible floor during normal operation. The thermal floor protector must have a minimum R-value of 1.0. Type 2 UL 1618 floor protector may be allowed ONLY if the particular it has an R value EQUAL TO OR GREATER THAN the minimum R value required in the appliance installation instructions can the protector be used. The manufacturer may specify an acceptable material and thickness for floor protection. That material may be the finish material, or a noncombustible decorative material (for example ceramic tile or brick) may cover the protective material and its heat transfer characteristics not be taken into account.

The first step is converting manufacturer and material specifications to appropriate terms. Factory-made hearth pads are required to express the thermal characteristics in R Values. Some appliance manufacturers may still express it in k values. If more than one material will be used (such as mineral board covered with ceramic tile), using or converting to R factor will be necessary.

In order to calculate and assess the results you must know:

- The k value of a material must be equal to or SMALLER than the required k value to be acceptable.
- The R value of a material must be equal to or LARGER than the required R value.
- You can add R values of different materials; you CANNOT add k values.
- k is expressed two ways:

1. k PER INCH of a material is the nominal expression of the amount of heat that will pass through a 1 inch section of a material in a given time.

2. k of an ACTUAL thickness of a material is an expression of the amount of heat that will pass through that particular thickness of the material.

Since manufacturers' instructions and reference materials state thermal properties in different ways, it is important to be able to convert from one form to another.

Converting k to R:

- Divide 1 by k and multiply the result times the thickness in inches of the material.
- R = (1/k) x inches of thickness

Converting R to k:

- Divide the inches of thickness by R.
- k = inches of thickness/R

4.2.5.2 Wall Protection

In the early days of the woodstove industry, manufactured or site built wall protection was often needed for reasonable and safe stove placement. Over the years, stove manufacturers have incorporated shields on the stoves that have allowed reduced clearances, typically without the necessity of wall protection. UL 1618 does provide testing methods and labeling instructions, however, for manufactured wall protection products.

As with site built clearance reduction methods outlined by NFPA 211, UL 1618 manufactured wall protectors cannot reduce clearances to less than 12 inches, unless the wall protector and appliance have been specifically tested and labeled together for lesser clearance.

4.2.6 UL1777 Standard for Chimney Liners.

UL1777 Chimney Liners covers metallic and nonmetallic (for example, poured) chimney liners intended for field installation into new or existing chimneys that are used for natural draft venting of Category I gas fired (natural draft such as Type B vent), Type L oil fired, and solid fuel residential type appliances in which maximum flue gas outlet temperatures do not exceed 1000°F. For woodstoves and inserts, UL1777 liners are tested to continuous temperatures of 1,000°F and maximum temperature of 2,100°F.

UL 1777 tested chimney liners are intended to be installed in existing masonry chimneys with or without an existing liner or fireclay tile, or to be used as a substitute for masonry fireclay tile flue liners in new chimneys. The liner instructions indicate the minimum clearance between the chimney structure and combustible materials and the type and amount of liner insulation required. Liner systems are not designed for use without a chimney surrounding them (for example, in a combustible chase that does not have a chimney in it).

4.2.7 UL737 Standard for Fireplace Stoves.

UL 737 Standard for Safety for Fireplace Stoves covers freestanding appliances that have fire chambers intended to be operated open to a room or, if equipped with doors, to be operated with the doors either open or closed. With early woodstoves, being able to view the fire required use of a screen because glass panels in appliance doors were either not available or stayed black and sooty most of the time. With the advent of higher combustion efficiency and glass air wash technology, fire viewing through the door glass became very effective and popular. Few appliances are now listed to UL 737.

4.2.8 NFPA 211 Standard for Fireplaces, Chimneys, Vents and Solid Fuel Burning Appliances.

This standard applies to the design, installation, maintenance, and inspection of all chimneys, fireplaces, venting systems, and solid fuel-burning appliances. Requirements cover the design, installation, maintenance, and inspection of chimneys, fireplaces, venting systems, and solid fuel-burning appliances in residential, commercial, and industrial occupancies. NFPA 211 reduces fire hazards by ensuring the safe removal of flue gases, the proper installation of solid fuel-burning appliances, and the correct construction and installation of chimneys, fireplaces, and venting systems.

4.2.9 ANSI Z21.50 Decorative Gas Appliances.

This standard applies to new vented gas fireplaces. For the purposes of this standard, a vented gas fireplace is a vented appliance that allows the view of the flames and provides the simulation of a solid fuel fireplace. These appliances are for use with natural gas or, propane. This standard applies to appliances that are not tested for efficiency.

Appliance types tested and listed under this standard include fireplaces, fireplace inserts and freestanding appliances. Gas fireplaces may be vented with Type B vent, direct vent, or approved chimney liner.

4.2.9.1 Requirements for Vented Gas Fireplace

An automatic gas ignition system with safety shutoff (spill switch) must be provided. A vent safety shutoff system is required for appliances equipped with draft hoods. It is designed to stop gas flow to the main burner if the venting system is blocked or otherwise venting poorly. Starting in January, 2015, strict glass temperature limits are specified or a certified barrier to prevent direct contact with the glass viewing area may be required.

4.2.9.2 Restrictions

Thermostats cannot be used to control appliances listed under this standard in the United States. In Canada, a vented gas fireplace installed in a bedroom or bedsitting room shall be certified with a thermostat and automatic ignition system.

4.2.9.3 Options

These appliances may use listed optional blowers to circulate heated air.

4.2.10 ANSI Z21.60 Decorative Gas Appliances for Installation in Solid-fuel Fireplaces.

This standard applies to gas log sets installed in working masonry and listed factory-built fireplaces and vented through their chimneys.

4.2.10.1 Requirements for Decorative Gas Appliances in Solid Fuel Fireplaces

- An automatic gas ignition system with safety shutoff must be provided.
- The appliance can only be installed in a solid-fuel burning fireplace with a working flue, constructed of noncombustible materials.
- The chimney damper must be fixed in a manner that maintains the minimum permanent vent opening. The manufacturer may require that the damper be fully open during operation.
- The operating instructions must include directions that a fireplace screen must be in place during operation.
- Periodic examination and cleaning of the venting system of the fireplace is called for.

4.2.10.2 Restrictions

Automatic thermostats cannot be used to control appliances listed under this standard.

4.2.11 ANSI Z21.84 Manually Lighted, Natural Gas Decorative Gas Appliances for Installation in Solid-Fuel Burning Appliances

This U.S. standard covers gas log sets that can be lighted manually (automatic ignition is required for vented gas log sets in ANSI Z21.60/CSA 2.26). These units are not allowed in many parts of the country.

4.2.11.1 Requirements for Vented Gas Fireplace Heaters

- Subject to efficiency requirements.
- An automatic gas ignition system with safety shutoff must be provided.
- A vent safety system with safety shutoff is required for appliances equipped with draft hoods.
- A certified barrier to prevent direct contact with the glass viewing area are available. Starting January 2015 they must be included and installed.

4.2.12 ANSI Z21.88/CSA 2.33 Vented Gas Fireplace Heaters

This Standard applies to new vented gas fireplaces that meet minimum efficiency requirements. These appliances are for: use with natural gas or propane. This standard applies to built-in fireplaces as well as freestanding fireplaces, free standing stoves and fireplace inserts that are tested for efficiency.

For the purposes of this standard, a vented fireplace heater allows the view of the flames and provides a simulation of a solid fuel fireplace. It is distinguished from a vented gas fireplace by being subject to efficiency testing. Gas fireplaces may be vented with Type B vent, direct vent, or approved chimney liner.

4.2.13 ANSI Z21.11.2 Gas-Fired Room Heaters, Unvented Room Heaters

This standard applies to new gas-fired unvented room heaters and gas-fired unvented decorative room heaters having input ratings up to and including 40,000 BTU/hr. (11,723 W). The standard refers to gas hearth products (gas log sets, fireplaces, and freestanding appliances) as decorative unvented appliances as an indication of their appearance, not function.

Combustion air requirements must be met. For rooms that are NOT bathrooms or bedrooms, unvented heaters cannot be installed in a confined space or in unusually tight construction unless provisions are made for adequate combustion and ventilation air or the minimum required volume of air must be determined and provided. For bathrooms and bedrooms, the room cannot be a confined space or it must have required volume, which can include directly communicating space.

The manufacturer's instructions may indicate that the unvented appliance is for installation only in a functional solid-fuel burning masonry fireplace, or in a functional UL 127 factory-built fireplace that has been tested, listed, and labeled for use with unvented gas log sets, or in a listed ventless firebox enclosure (appliance not exceeding 40,000 BTU/hr). Unvented heaters may be controlled by an automatic thermostat. Unvented heaters may use listed blowers.

4.2.13.1 Requirements for Unvented Room Heaters

These appliances must be equipped with an oxygen depletion sensor (ODS) that works with the gas safety shut off valve to shut off fuel flow in the event of low oxygen levels.

4.2.13.2 Restrictions

An unvented room heater can be used in a bedroom or bathroom under certain conditions, which may include approval by local code authority. Code and standard issues may include the following:

- An unvented appliance is limited to 6,000 BTU/hr input in a bathroom and 10,000 BTU/hr input in a bedroom.
- According to the National Fuel Gas Code (NFGC) and the International Fuel Gas Code (IFGC), an unvented heater suitable for use in bathrooms and bedrooms must be wall-mounted. ANSI Z21.11.2 Unvented Room Heaters allows unvented gas log sets that are "provided with means for mounting the burner base assembly to the floor of the solid-fuel burning fireplace" to be considered as complying with the wall-mounted requirement for installation in bedrooms and bathrooms.
- Local code may vary on some of these requirements.

4.2.14 ANSI Z21.97 Outdoor Decorative Gas Appliances

This standard defines outdoor spaces and outdoor gas hearth appliances, establishes materials, construction, venting, installation instruction and other requirements. ANSI Z21.97 provides minimum requirements for construction, performance, and testing. As with other product testing, the standard provides safety warnings and information requirements that must be provided in the manufacturer's installation and operation instructions. While much of the standard is similar or identical to standards for indoor gas hearth systems, there are differences that manufacturers of outdoor gas hearth appliances must conform to.

Definitions

ANSI Z21.97 includes these fundamental definitions of the appliances it covers and the area where they are used:

Outdoor Decorative Gas Appliance. An appliance for use in outdoor spaces only and whose primary function lies in the aesthetic effect of the flame.

Outdoor Spaces. An appliance is considered to be outdoors if it is installed with shelter no more inclusive than:

- With walls on all sides, but with no overhead cover;
- Within a partial enclosure which includes an overhead cover and no more than two sidewalls. These sidewalls may be parallel, as in a breezeway, or at right angles to each other; or
- Within a partial enclosure which includes an overhead cover and three sidewalls, as long as 30% or more of the horizontal periphery of the enclosure is permanently open.
- We will see in our discussion the relationship of these maximum shelter specifications to ventilation and venting, and ultimately to appliance performance.

Outdoor Appliance Construction Requirements. Requirements for ANSI Z21.97 listed outdoor hearth appliances that are not found in indoor hearth appliance standards include:

- Loose burner media that could be damaged or moved by wind is not to be used.
- Ferrous (iron) materials used in appliance construction are coated to protect against corrosion.
- Ceramic fiber burner bodies and porting are not to be used in outdoor gas fireplaces.

LP Gas Supply. Propane cylinders compatible with the appliance and manufacturer's instructions can be used with outdoor gas hearth appliances. ANSI Z21.97 includes ventilation requirements enclosures for these cylinders that must be met by the appliance manufacturer when supplied with the appliance.

Safety Testing.

- In addition to these appliance construction and fuel supply requirements, there are two significantly different testing procedures that outdoor gas hearth appliances are subjected to.
- Outdoor gas hearth appliances are subjected to a number of tests to ensure that moisture, such as rainfall, does not compromise the safety or proper functioning of these appliances.

- Appliances that are equipped with electrical equipment and wiring operating at 120 volts are further tested for current leakage and integrity of electrical insulation.
- Appliances with glass fronts are operated for 1 hour at an increased test pressure, then subjected to the rain test for 5 minutes. At the conclusion of exposure to the simulated rainstorm, there cannot be any cracking, crazing, or breaking of the glass.

Outdoor gas hearth appliances are also tested to ensure that they operate properly in moderate wind conditions. Under these conditions, the appliance must meet these requirements:

- A pilot must be capable of being lit
- The main burner must ignite from its ignition device without excessive delay
- The main burner flame not become extinguished by the wind
- Appliances without automatic safety shut-off devices must not become extinguished when exposed to a wind velocity of 31 miles per hour.
- A barrier to prevent direct contact with the glass viewing area must meet testing requirements that include glass viewing coverage area, acceptable burn potential test, maintaining shape and position under force, prevention of finger penetration at top, sides, and bottom. Such a barrier, typically a metal screen, must be included with Outdoor Decorative Gas Appliances starting in January 2015.

4.2.15 Gas Hearth Appliance Standards Summary

Standard	Requirements	Restrictions	Options
ANSI Z21.50/CSA 2.22 Vented fireplaces	Automatic ignition system with safety shutoff Vent safety shutoff if draft hood equipped.	No thermostat	Listed blowers
ANSI Z21.60/CSA 2.26 Decorative log sets for fireplace installation	Automatic ignition system with safety shutoff Working Fireplace and chimney Permanent damper opening Cleaning of venting system	No thermostat	
ANSI Z21.88/CSA2.33	Automatic ignition system with safety shutoff Vent safety shutoff if draft hood equipped.		Thermostats Listed blowers
ANSI Z21.11.2a Unvented room heaters	Automatic ignition system with safety shutoff	Bedroom & bathroom restrictions Confined space restrictions	
ANZI Z21.97 Outdoor decorative gas appliances	Defined outdoor spaces Appliances designed for outdoors (wind & moisture requirements)	Outdoor use only	Propane cylinder enclosure

4.2.16 ASTM E 1509, Standard Specification for Room Heater, Pellet Fuel-Burning Type

This specification covers performance requirements, test methods, and marking requirements for automatic feed, pellet fuel-burning room heaters that are intended to burn wood pellets or other suitable solid fuel.

Some of the features related specifically to pellet appliances and found exclusively in this standard include:

- Maximum temperature increases during testing for internal fuel hopper surfaces.
- Fuel hopper construction. Since 2004, the standard has required that the hopper lid have a direct interlock to the fuel auger so that the auger is disabled when the hopper is opened.
- The appliance must remain operational without tripping overheat sensors and without exceeding temperature limitations

when the convection blower speed control is at its lowest setting and the fuel feed control is at its highest setting.

- Negative pressure tests to ensure that the appliance does not permit unsafe carbon monoxide concentrations and to ensure that burn back (smoke within the hopper, or smoldering or charred pellets) into the fuel hopper does not occur.
- Temperature tests that include disabling motors and blowers individually and in combination.
- Test structure specifications for both vertical and horizontal venting installations and which can serve for conventional housing, mobile home, and alcove testing.
- Inclusion in operating instructions of details such as startup and shutdown procedures, fuel requirements, soot and fly ash removal.

4.2.17 Manufactured/Mobile Home Requirements

The U.S. Department of Housing and Urban Development (HUD) has established rules for mobile home appliances. According to HUD regulations, appliances installed in mobile homes must be specifically tested and listed for use in mobile homes. Fireplaces and woodstoves listed for installation in mobile homes have special HUD requirements that include:

- Installation according to terms of listing and manufacturer's instructions
- Outside air kit that attaches directly to the appliance
- Securing of appliance to mobile home structure
- Listed factory-built chimney with listed rain cap with spark arrestor
- No installation in a sleeping room
- Separation of the combustion system from the interior atmosphere of the home allows, as one means of accomplishing that separation, direct vent appliances

4.2.17.1 Fuel Gas Code Aftermarket Appliance Requirements

The National Fuel Gas Code permits installation of gas appliances in mobile homes after the initial sale, including unvented appliances, if listed or approved for use in manufactured housing and installed in accordance with the NFGC requirements (including combustion air requirements) and the manufacturer's instructions. The International Fuel Gas Code makes no mention of manufactured housing appliance requirements. State and local codes may vary with regard to regulation of aftermarket installations in mobile homes.

4.3 Codes

Standards have the force of law when they are adopted and enforced by a code authority. The organization, office, or individual responsible for enforcing the requirements of a code or standard, or approving equipment, installations, or a procedure is known as the "authority having jurisdiction (AHJ). Where public safety is primary, the 'authority having jurisdiction' may be a federal, state, local, or other regional department, or even be an individual such as a fire chief, fire marshal, chief of a fire prevention bureau, official of the labor department, health department, building official, electrical inspector, or other person having authority under the law. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the 'authority having jurisdiction.

NFPA 211 and IRC grant the AHJ, who is designated by the governing authority, to approve, with substantiation of safety, equivalent materials, construction methods, or installation procedures. In practical terms, it is the AHJ that typically makes final interpretations and decisions. An appeal process normally resolves serious conflicts over code decisions.

4.3.1 Local Codes

Interpretation of codes, standards, and installation instructions is often finally administered by a local building official. In areas where there are no local codes or building officials, it is strongly suggested that manufacturers' instructions and specifications and national standards of practice such as provided by NFPA and IRC be followed carefully. In the event of problems, demonstration of knowledge and strict adherence to such practices can be extremely important.

Some states make amendments or additions to codes and publish state versions of the codes. Local jurisdictions may also have additional requirements.

4.3.2 Applicability and Retroactivity

NFPA 211 and IRC do not call for the provisions of the current code to be applied retro-actively to existing systems that were in compliance with the provisions of the code that was in effect at the time of installation.

Many jurisdictions lag slightly or far behind current editions of the codes. There may be cases where a planner or installer would prefer to follow regulations from a newer version than the currently adopted version of the code. If the newer provision is stricter than the current one, there should be no problem in exceeding the demands of the current edition. If the new provisions are less strict or substantially different from the current edition, it would be necessary to seek approval from the AHJ.

4.3.3 Recognition of Manufacturers' Instructions

IRC defers to the manufacturers' instructions of listed products. IRC specifically states "Where enforcement of a code provision would violate the conditions of the listing of the equipment or appliance, the conditions of the listing and the manufacturer's instructions shall apply". NFPA 211 does not state this principle directly, but throughout the standard references manufacturer's instructions of listed equipment.

4.3.4 Conflicts in Requirements

The wide variety and complexity of appliances, venting systems, construction, and other factors results understandably in gray areas where manufacturers' instructions, code requirements, and AHJ interpretation are either in conflict or not entirely applicable to a particular situation. If the conflict is between manufacturer's instructions for a listed, tested product, usually the manufacturer's requirements prevail. Where there is involvement of the AHJ, generally his/her interpretations prevail, though they may be subject to appeal through a formal process. In cases where there is conflict or ambiguity about a requirement, one path to resolution is to accept and carry out the strictest choice.

Great care must be exercised in paying close attention to detail. Code language is sometimes not user friendly, but the intention is precise language that reduces individual interpretation. One aspect of attention to detail is also a part of finding relevant regulations: noting exceptions.

4.4 Codes Applicable to Hearth Appliance Installation

4.4.1 International Residential Code (IRC)

This comprehensive, stand-alone residential code establishes minimum regulations for one- and two-family dwellings and townhouses using prescriptive provisions. The IRC contains a complete set of code provisions, covering all aspects of construction in a single source, including:

- Building
- Plumbing
- Energy conservation
- Mechanical
- Fuel gas provisions included through an agreement with the American Gas Association
- Electrical provisions from the 2014 National Electrical Code® (NFPA 70)

4.4.2 International Building Code (IBC)

The IBC applies to all occupancies, including one- and two-family dwellings and townhouses that are not within the scope of the IRC. The IRC is referenced for coverage of detached one- and two-family dwellings and townhouses. The IBC applies to all types of buildings and structures unless exempted.

4.4.3 International Mechanical Code (IMC)

The purpose of the code is to establish the minimum acceptable level of safety and to protect life and property from the potential dangers associated with the installation and operation of mechanical systems. The code also protects the personnel that install, maintain, service, and replace the systems and appliances addressed by this code. The code relies heavily on product specifications and listings to provide much of the appliance and equipment installation requirements.

4.4.4 International Fuel Gas Code (IFGC)

The IFGC addresses the design and installation of fuel gas systems and gas-fired appliances through requirements that emphasize performance.

4.4.5 International Existing Building Code (IEBC)

The IEBC contains requirements intended to encourage the use and reuse of existing buildings. The scope covers repair, alteration, addition, and change of occupancy for existing buildings and historic buildings, while achieving appropriate levels of safety without requiring full compliance with the new construction requirements contained in the other I-Codes.

4.4.6 NFPA 54 National Fuel Gas Code

NFPA 54 provides minimum safety requirements for the design and installation of fuel gas piping systems in homes and other buildings. Requirements cover the installation and operation of fuel gas systems, appliances, equipment, and related accessories, with rules for piping systems materials and components, piping system testing and purging, combustion and ventilation air supply, and venting of gas-fired appliances and equipment.

4.5 EPA's New Source Performance Standard (NSPS)

The high public interest for the solid fuel products that offered homeowners a degree of energy independence and self-reliance in the 1970's was dimmed in the 1980's as the woodstove industry learned of and began to deal with its air pollution problems. The ability of the industry to meet phased in standards of lowered particulate emissions has resulted in a new generation of improved products. While open fireplaces have not been regulated at the national level, some jurisdictions have imposed limitations or bans on them, and research continues for testing standards and improvements. The first regulatory negotiation by EPA the late 1980s required woodstove manufacturers to design and produce heaters to meet particulate emission limits, have representative models be tested by EPA accredited labs, and attach EPA labels and hang tags after approval. Particulate emissions for affected appliances were required to be limited to:

- 4.1 grams/hour (catalytic)
- 7.5 grams/hour (noncatalytic)

To meet these regulations, emissions levels of older, conventional wood burning appliances had to be reduced by approximately 80%. The differences between catalytic and noncatalytic standards were the result of original expectations of catalyst deterioration and/or failure, and the potential for them not to be replaced. Recent studies funded by catalytic combustor and stove manufacturers indicate that advancements in combustor design and protection have resulted in increased longevity, also indicated in low numbers of warranty combustor replacements.

These national regulations have applied to all new wood burning appliances with a few exceptions:

- Minimum burn rates greater than 5 kg/hour, or about 11 pounds of wood per hour
- Average air-to-fuel ratio of more than 35to1
- Usable firebox volume of larger than 20 cubic feet
- Weight more than 800 kilograms, or about 1,760 pounds

These definitions and other considerations exempted coal burning appliances and open fireplaces, cook stoves that have ovens, solid fuel furnaces and boilers, and large industrial and commercial wood fired appliances.

Field tests were conducted in the late 1980's and early 1990's to compare "real world" performance of certified solid fuel appliances against theoretical expectations and earlier appliance performance. These studies confirmed performance expectations and showed dramatic improvements by certified appliances over earlier appliances. The study in Klamath Falls, Oregon, revealed that earlier EPA emissions estimates of non-certified appliances were exceeded greatly (doubled) in actual use. The average certified appliance emissions in this study were 6 kg/hour, a reduction by more than 85% of the emissions of non-certified units. A study conducted in Crested Butte, Colorado, showed a 60% improvement in the town's visual air quality.

Recent Developments in Emissions Regulations. Until 2015, the EPA regulations had not changed since their inception in 1988. In joint efforts between EPA and the HPBA, many change out programs have encouraged customers to replace their old stoves and with new clean burning EPA approved appliances. The HPBA worked with EPA to start a training and consumer awareness program about proper use, firewood selection and maintenance through the Burn Wise program.

In May, 2015 a revised set of EPA regulations went into effect. The new NSPS eliminated most of the exemptions that were permitted in the first version and tightened the emissions standards even more. The new standard has two different sets of requirements.

Step 1 was put in place requirements for wood and pellet stoves, hydronic heaters, and forced-air furnaces.

Wood and pellet stoves have a 4.5 gram per hour limit. Hydronic heaters have a 0.32 pounds per million BTU limit. Forced-air furnaces have a 0.93 pounds per million BTU limit.

Under the original NSPS regulations, EPA certification for a stove model was valid for five years. Stove lines that held a current EPA certification before the effective date of May 2015 can continue to be produced and sold through May 15, 2020.

Step 2 is scheduled to go in to effect on May 15, 2020. It will bring the limit for wood and pellet stoves down to:

- 2.0 grams per hour if tested with crib wood
- 2.5 grams per hour if tested with cordwood

The hydronic heater limit goes down to 0.10 pounds per million BTU or 0.15 pounds per million BTUs if tested with

The regulations have gone virtually unchanged since 1992, with EPA and HBPA efforts focused on emissions reductions through cooperative efforts:

- To replace preEPA stoves in regional stove changeouts to encourage installation and planning of systems by qualified professionals such as NFI Certified Woodburning Specialists (see www.epa.gov/burnwise).
- Some twenty five years after inception, a major revision was implemented starting in 2015.

Appliances covered under the new regulations

- Room heaters
- Woodstoves and fireplace inserts
- Pellet stoves
- Central heaters
- Outdoor/indoor hydronic heaters
- Forced air furnaces
- Masonry heaters

Exempt appliances

- Existing heaters currently in use in people's homes
- Outdoor fireplaces, pizza ovens, barbecues, firepits, chimineas, Native American bake ovens, ceremonial fires
- Heaters fueled solely by oil, gas, coal
- New indoor fireplaces

cordwood. The forced-air furnace limit will drop to 0.15 pounds per million BTU.

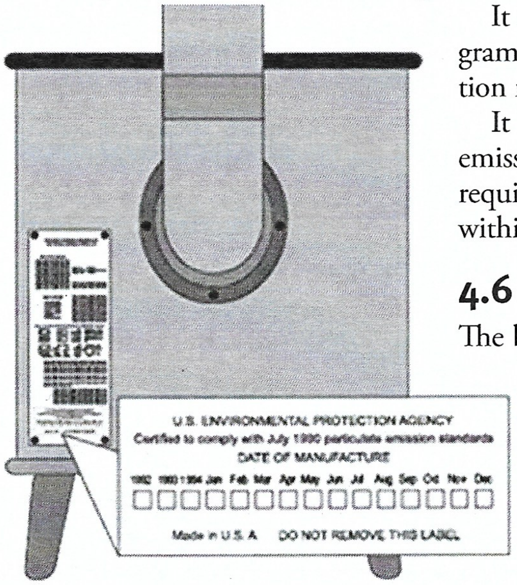
Appliances must be certified to Step 2 by May 15, 2020. Appliance that are not certified to Step 2 cannot be sold after that date. EPA allows a voluntary hang tag that may be displayed that are certified to Step 2. HPBA is currently pursuing an extension to the May 15, 2020 effective dates for manufacturers and for retailers to sell appliances that are certified to Step 1 but not Step 2. Until such efforts are successful, the May 15, 2020 remains final.

Fireplace Emissions Regulations. Recent discussion regarding open fireplaces in the NSPS process has been of major interest to the hearth industry. The concept of voluntary low emission fireplaces originated within the hearth industry before NSPS proceedings. Consumer advocate groups have pointed to the higher levels of emissions inherent in the less efficient design of fireplaces, while hearth industry interests have pointed to the low overall impact of these infrequently used appliances.

During these discussions, a cooperative effort has resulted in the EPA Woodburning Fireplace Program. This voluntary program was undertaken to encourage the development and sale of a new generation of lower emitting woodburning fireplaces. It covers new masonry and factory-built (identified as "low mass" in EPA terminology) fireplaces, but not retrofit devices for existing fireplaces.

Fireplace manufacturers participate in the program by testing fireplace units in order to have them "qualified" (not certified) by EPA. These fireplaces must meet an emission level of 5.1 g/kg or lower. The manufacturer includes information in the owner's manual about proper operation and maintenance of the fireplace, including proper fuel. And the manufacturer provides sale and test data on improved fireplaces to EPA.

For its part, EPA provides labels that identify which models meet program requirements and outreach and educational materials. Current EPA Fireplace Program partners and a list of qualified fireplaces are available at http://www.epa.gov/burnwise/fireplacepartners.html and http://www.epa.gov/burnwise/fireplacelist.html, respectively.


U.S. ENVIRONMENTAL PROTECTION AGENCY
Certified to comply with July 1990 particulate emission standards
DATE OF MANUFACTURE
1992 1993 1994 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
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Made in U.S.A.
DO NOT REMOVE THIS LABEL

It is important to understand that fireplaces "qualified" under this voluntary program are not certified by the EPA requirements under NSPS, and may have installation restrictions in some jurisdictions.

It is also important for planners and installers to understand that qualified low emission fireplace systems may tend to be less forgiving of poor draft and therefore require careful attention to details such as venting height and position of the chimney within the building envelope.

4.6 Green Building Codes and Standards

The building codes provide minimum requirements for life safety and building and property protection. The energy code adds minimum requirements for efficient use of resources and energy sources. These green codes and standards have been (and are being) developed to define additional and alternative exemplary approaches to building construction and materials that will overlay and not conflict with basic building codes and standards. These documents are sometimes referred to as "overlay" or "reach" codes and standards.

4.6.1 International Energy Conservation Code (IECC)

The primary effort with regard to an energy code addressing the design of energy efficient buildings and installation of energy efficient mechanical, lighting, and power systems is the International Energy Conservation Code (IECC). Where adopted, this code establishes minimum regulations for energy efficient buildings.

The 2009 IECC required that new wood burning fireplaces have gasketed doors and outdoor combustion air. Numerous questions were raised about the application to all new masonry and factory-built fireplaces and a potential violation of manufacturer's instructions for listed UL 127 factory-built fireplaces. Other questions about the unknown effect on masonry fireplace clearances were also raised. The issue was allowed to follow the normal course of code development process, with revision undertaken in the 2012.

That brought mixed and unfortunately confusing results in the 2012 IECC and IRC. Both replaced the text section that called for new woodburning fireplaces to have gasketed doors with language that called instead for tight fitting flue dampers. But the Code Committees also approved a table that contained the language requiring gasketed doors and air barriers for new fireplaces. The 2015 IECC revision cleared up these issues and simply requires new woodburning fireplaces to have tight fitting flue damper or doors and outside combustion air. For UL 127 factory-built fireplaces, the doors must be tested and listed for the fireplace. For masonry fireplaces, tight fitting doors must be listed and labeled in accordance with UL 907 Fireplace Accessories.

4.6.2 Leadership in Energy and Environmental Design (LEED)

LEED is a voluntary green building certification program developed by the U.S. Green Building Council (USGBC), a nonprofit organization promoting energy saving buildings. LEED provides rating systems that provide builders criteria to follow to achieve LEED certifications. The criteria are a combination of basic requirements and additional points for practices or materials recognized as enhanced measures. The basic requirement for fireplaces and woodstoves is that they must have doors. Additional points can be awarded if the home has no fireplace or woodstove. If one is installed, a point is awarded for a fireplace or woodstove/insert that is EPA certified.

4.6.3 National Green Building Standard (ICC 700)

Developed by the National Association of Home Builders (NAHB), ASTM International, and the American Institute of Architects (AIA), and adopted by the International Code Council (ICC), ICC 700 provides criteria for rating the environmental impact of residential building design and construction practices. This voluntary standard provides a rating system with progressive performance levels determined by meeting minimum point levels in building categories (such as energy efficiency, water efficiency, indoor air quality, etc.) and minimum overall point totals. These points are awarded for practices and materials above identified mandatory minimum requirements.

The current point system awards points for not installing hearth products or various points for meeting requirements when they are installed, including fireplaces and woodstoves/inserts that are safety listed and EPA certified. The issue of woodburning fireplaces being equipped with gasketed doors and designed to operate with the doors closed (and a means to seal the flue to minimize interior air and heat loss) is included and awarded points, but the standard specifically indicates that these gasketing and sealing provisions are not mandatory.

Chapter 5 Venting Systems

5.1 Principles of Draft and Flow

Most customers think of the chimney as a way to get smoke out of the house and as an added expense. In fact, the chimney not only removes exhaust, but it is also responsible for supplying the combustion air that starts and sustains the fire. Warm gases rising from the fire create the vacuum effect at the appliance opening that supplies combustion air to the fire.

As both the means of moving air into the fireplace and moving smoke and gases to the outdoors, the chimney is a crucial part of the venting system. It, in fact, drives the system. The venting system must also protect nearby combustibles from sustained high temperatures and from the extreme temperatures of a chimney fire. It must also protect the roof and other nearby objects from sparks and smoke damage.

Given the importance of the venting system, it should be clear that understanding the basic principles of draft and flow are essential for planning, assessing, and installing chimneys.

5.1.2 Natural Draft

Natural draft is a relatively weak force that is affected by a number of factors. Heated gases have a tendency to rise (buoyancy). The difference in temperature between rising heated gases and the surrounding atmosphere creates a measurable force that results in gases flowing from zones of high pressure to zones of low pressure. The term that describes and quantifies the force causing gases to flow is draft. The greater the temperature difference between the heated gases in the flue and the cooler air outside the vent, the more natural draft (more force) is created.

5.1.2.1 Factors Determining Natural Draft

Since natural draft is a function of the temperature differences between flue gases and outdoor air, the following variables can produce and affect that difference:

- **Vent gas temperature.** The hotter the vent gases, the lighter they are and the more forcefully they exit the venting system.
- **Outdoor temperature.** Colder weather is better for draft because it produces a bigger temperature (and pressure) differential.
- **Ability of the vent to hold heat.** Excessive cooling of vent walls, however, has a negative effect on draft. As flue gases move through the venting system, they lose heat to the vent or chimney walls. As the gases cool, they become less buoyant. The ability of the venting system to retain heat is therefore an important design consideration. In cold climates, it may be necessary to install as much of the venting system as possible within the building envelope, to provide an insulated chase for weather protection, or to use an insulated vent or liner. In general, single wall metal and masonry materials allow gases to cool much more than double wall or insulated gas vents.
- **Height of the vent.** Increasing the height of a column of hot gases generally increases the force of the air displacing them. There is a limitation to this concept since increased vent length also increases flow resistance and cooling of gases. Excessive chimney height may cause excessive draft which will cause fuel to burn too rapidly. (A draft hood on B-vent gas appliances minimizes the effect of vent height by the effect of air drawn in through its opening.

5.1.3 Flow

The second factor at work in a venting system is flow. Flow is the volume of gases that pass through the venting system as a result of draft. While draft is the force that moves gases, the amount of flow determines whether the venting system performs successfully. There must be sufficient flow to remove flue gases at the rate they are produced and to provide adequate combustion air. Flow and draft are interdependent, but it is important to make distinctions between them in order to understand and isolate the factors that produce or prevent successful venting.

Natural Draft: the force of the pressure difference created in a venting system by the temperature difference between the gases in the venting system and the outdoor air. That negative pressure can be measured by a manometer or digital pressure gauge in Pascals or in water column inches.

Mechanical Draft: the force of the pressure difference created in a venting system by an electrically powered fan. The pressure in the vent is positive if the fan is located immediately between the appliance and the vent or before the appliance; it is negative if the fan is located at the termination of the vent.

Flow: the volume of gases that pass through a venting system as a result of draft. Resistance to flow has the net effect of reducing the results of draft.

Negative pressure: less than normal atmospheric pressure.

Positive pressure: greater than normal atmospheric pressure.

5.1.3.1 Factors Determining Flow

Flow and natural draft are interdependent, but it is important to make distinctions between them in order to understand and isolate the factors that produce or prevent successful venting. The primary factors that affect how much and how well gases move through a venting system (flow) include:

- **Natural draft.** With all other factors equal, the stronger the force generated by temperature difference between flue gases and outside air (draft), the greater the volume of gases that move through the system (flow). Likewise, weaker draft produces less flow.
- **Cross-sectional area.** The size of the flue is a determining factor for the amount of gases that can move through the system in a given time period. The amount of flow possible in a venting system is known as flow capacity. The general rule that the larger the flue, the greater the flow capacity, has an important exception. Increasing the flue size significantly beyond the area of the appliance flue collar has the effect of reducing natural draft due to the cooling effect of flue gases moving more slowly through the system and due to their losing more heat to the larger surface area of the flue. See relationship of draft and flow, below.
- **Resistance to flow.** Gases moving through a venting system encounter constant friction, or resistance to their flow. While a certain amount of resistance is unavoidable, there are variables in venting system components and configuration offering different amounts of resistance. These variables include turns (elbows, tees, offsets), horizontal runs, obstructions, wind, and competing sources of negative pressure.

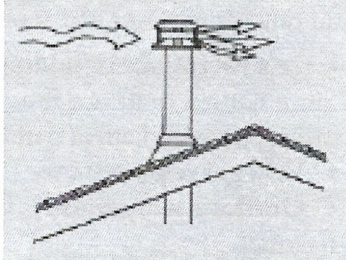
5.1.4 Relationship of Natural Draft and Flow

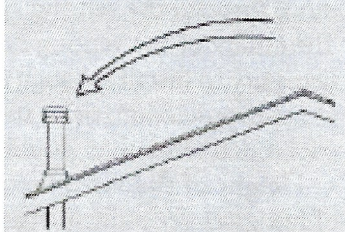
Essentially anything that affects the difference between the temperature of flue gases and the outside atmosphere affects draft. When isolating factors that affect draft in planning or troubleshooting, for example; adequate heat production, ability to retain heat, and flue height are the primary concerns. For flow, the primary concerns are adequate draft, adequate capacity (size), and factors affecting resistance to flow.

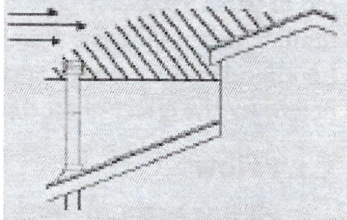
It is also necessary to be able to assess the interaction of draft and flow. While draft has an immediate and obvious effect on flow, factors that affect flow eventually affect flue gas temperature, and therefore affect draft. For example, restrictions to flow reduce not only the amount of gases moving through the venting system, but also the amount of combustion air drawn into the appliance. If combustion air is reduced, flue gas temperatures and draft decrease.

Factors that indicate the close relationship between draft and flow include:

- **Restrictions to flow.** Any restrictions that slow gas flow, such as undersized vents, changes in venting directions (elbows, tees, and bends), obstructions or blockage, can affect draft adversely by affecting the combustion process and resulting lower flue gas temperatures.
- **Wind.** Wind blowing over the top of a vent can assist draft (and possibly cause over drafting) in a fashion similar to that of air flowing over an airplane wing. When this occurs, the wind acts as a motivating force and "lifts" the products of combustion by causing a greater negative pressure at the termination than that existing in the vent stack. This action temporarily increases draft in the venting system. On the other hand, wind blowing into the vent can adversely affect draft. Wind blowing against a nearby structure taller than the vent can create a positive pressure zone that increases resistance to flow.
- **Appliance Operation.** The operator can take a number of actions that reduce or increase available heat for the chimney (amount of fuel, air, startup technique) or that play into the hands of external forces (operation during warm weather, operating powerful exhaust devices, opening windows that affect house pressure).


Wind: driving pressure


Wind: adverse pressure


Wind: adverse pressure

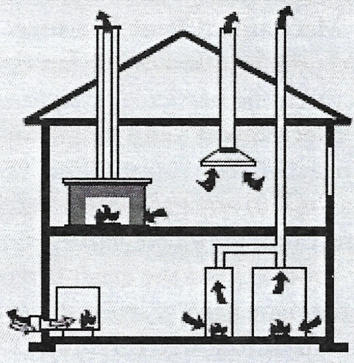
5.1.4.1 Pressure Conditions in the House

Tight construction for energy efficiency reduces the outdoor air exchange rate and the available supply of combustion air. Difficult startup, poor performance, and smoke spillage can result from inadequate combustion air supply. Planning should include attention to house construction characteristics, competition for air supply, and effective provisions for a source of combustion air. If there is a force within the house that creates stronger negative pressure than the appliance venting system can produce, flow is reduced and draft may be compromised or overcome. Results can include incomplete combustion resulting in increased creosote buildup and spillage of combustion by-products into the home.

Competing sources of negative pressure include:

- Exhaust devices such as bathroom and/or kitchen range exhaust fans (particularly downdraft kitchen range exhausts)
- Radon mitigation fans that extract radioactive gases from below the house and exhaust them above the house
- Appliances such as clothes dryers and central vacuum units
- Combustion appliances such as gas furnaces and water heaters
- Leaking furnace ductwork (but supply registers can create positive pressure)
- Additional hearth appliances, particularly an upstairs solid fuel open fireplace (or one with a gas log set)

Sources of negative pressure



NOTE: DIRECT VENT APPLIANCE IN ILLUSTRATION DOES NOT AFFECT HOUSE PRESSURE.

SOURCES OF NEGATIVE PRESSURE

An instrument used to measure air tightness of a building is called a blower door. Comprised of a calibrated, variable speed fan and a pressure measurement device. In the past, blower door tests for hearth appliance installations were rare. The new building codes require builders to seal new construction up tighter. Natural draft appliances and even some mechanical draft appliances may have trouble operating properly. A blower door test is the best way to determine exactly what is required for the appliance to work.

5.1.4.2 Application of Principles of Draft and Flow

The principles of draft, flow and ventilation affect practical decisions about woodburning venting systems. The concern is the interrelated requirements of adequate exhaust removal and supply of combustion air. "Adequate" is a relative term, since different appliances have different specific needs that must be known. In general, open fireplaces require much more air for operation than woodstoves, both for combustion purposes and dilution (excess) air that passes through the system.

Unless forced by mechanical or other means (for example a fan/blower), air always moves from a zone of higher pressure to one of lower pressure. The pressure inside a working chimney is lower than that outside it because of the temperature difference within and out side. As air and gases in the firebox moves to the lower (negative) pressure zone of the chimney, air enters the appliance because its pressure is lower than the air pressure at its opening. The incoming air is essential to the combustion process.

The strength of draft plays a large role in whether an adequate supply of combustion air feeds the fire. As we have seen, natural draft is a relatively weak force that is affected by a number of factors, including the amount of heat available from the fire, outside temperatures, the ability of the chimney to hold heat, the height of the chimney, the size of the chimney, the resistance of the venting system, as well as the tightness of the house, weather conditions, and competition with exhaust and other combustion devices.

The fuel gas codes allow vented appliances to use mechanical draft systems under these requirements

- Systems must be listed and installed in accordance with both the appliance and mechanical draft system manufacturer's installation instructions. Note: Check with the appliance manufacturer's for prohibitions regarding mechanical venting.
- Vents under positive pressure must be designed and installed to prevent leakage into a building.
- The mechanical draft system must provide for shutdown of gas flow in gas appliances to the main burner if the draft system does not satisfy the operating requirements of the appliance for safe performance.
- Termination requirements for mechanical draft systems must be met.

5.1.4.3 Mechanical Draft

In some cases, design considerations or venting system performance necessitate using mechanical venting systems. Mechanical venting may also be used as a retrofit to correct venting problems. Mechanical venting systems must be listed to appropriate standards, approved for use by the appropriate manufacturers, and/or meet applicable code requirements as approved by the building official or other authority having jurisdiction.

The types of mechanical vent systems, listing and installation requirements vary for different types of conventional and direct vent hearth appliances, as well as for non-condensing and condensing appliances. Sizing and installing mechanical draft systems should be undertaken by qualified technicians carefully following manufacturer's instructions.

Mechanical Vent Pressure. Whereas natural draft is always negative pressure, drawing combustion air into the appliance, the location of the fan determines the pressure of power vents. There are several locations, depending on the manufacturer, the particular system employed, and the type of appliance. It is important to know and understand vent pressure.

Mechanical Vent: Negative Pressure. If the fan is located at the end (termination) of the vent, the pressure in the vent is negative. For conventional vent appliances, the fan pulls combustion air through the appliance and venting system. Air is drawn into any gaps in the venting system. For direct vent appliances, the fan is essentially sucking combustion air into the direct vent air intake termination, through the intake pipe, into the combustion chamber, and then pulling the combustion by-products out the exhaust pipe, through the fan itself and pushing them out under positive pressure into the atmosphere. If there are gaps or leaks in the exhaust pipe in this system, air is drawn into the pipe. Pipe and system sealing instructions should be followed carefully.

Mechanical Vent: Positive Pressure. There are two locations for positive pressure power vents. In one, the fan is located below the firebox. The firebox and the venting system are under positive pressure. In the other approach, the fan is located between the firebox and the venting system. The firebox is under negative pressure as combustion air is drawn into the intake pipe of the direct vent and through the firebox. The combustion by-products are pulled through the fan and pushed under positive pressure through the exhaust pipe of the direct vent. In either case, positive pressure requires proper sealing of the system. Instead of air being drawn into gaps in a negative pressure system, combustion by-products are pushed out through gaps. Such release of potentially harmful exhaust must be prevented by sealing according to manufacturer's instructions.

Mechanical Draft: Flow. Flow is the volume of gases that pass through the venting system as a result of draft, whether natural or mechanical. While draft is the force that moves gases, the amount of flow determines whether the venting system performs successfully. For all venting systems there must be sufficient flow to remove flue gases at the rate they are produced and to provide adequate combustion air.

However, larger cross-sectional areas in mechanical draft systems create less resistance to flow with mechanical draft.

Some factors which affect flow in natural draft systems have the same effect on mechanical draft systems:

- **Draft strength.** All other factors being the same, stronger draft creates greater flow in both draft systems.
- **Change in direction.** Elbows and tees create resistance to flow in both draft systems.
- **Wind.** Can create resistance to flow.

5.1.5 Draft Gauges

Use of an instrument for measuring draft pressure (known as draft gauge, draft meter, magnahelic, manometer, or pressure gauge) is an important process in setup, operational check, and troubleshooting for natural draft appliances. Hearth professionals are able to quantify actual venting system pressure and compare those results to the appliance manufacturer's specifications.

There are many types of draft gauges, each with its own characteristics, advantages and disadvantages:

1. U-tube or slack tube manometer: A U-shaped tube, one end of which contains fluid and is marked with a graduated scale for measuring, is open and the opposite end is connected to the low-pressure source. The fluid in the tube is moved or displaced by slight pressure changes and the change can be read on the scale, which is calibrated to read directly in the desired units of measure. Inexpensive, but somewhat cumbersome to use.

2. Differential pressure gauge: A gauge that indicates pressure changes to a precision diaphragm, typically with a round dial or horizontal gauge with a free floating needle indicator. Low to moderate cost.

3. Digital draft gauge: electronic measurement and reading of draft pressure with a digital readout. Digital gauges may offer features such as hold to freeze the display and then return to actual measurement or the ability to capture minimum and maximum values read. Moderate to expensive, depending on features.

Chimney draft is measured in water column inches (WCI) or Pascals (Pa). One inch water column equals 249 Pascals, and one Pascal equals .004 water column inch. Twenty seven inches of water equals 1 pound per square inch (psi). A range of 0 to -1.0 WCI is usually considered adequate for typical pellet systems measurements and 0 to -.25 WCI is usually considered adequate to woodburning systems.

5.2 Chimney Connectors

Chimney connectors perform the important function of joining the appliance to the chimney. The most common use is with woodburning freestanding stoves. Connector pipes may also be used in some gas and pellet installation, although that is very rare. Factors concerning chimney connectors in installation planning include concerns about clearances, draft, and creosote accumulation. Connector clearance may be the determining factor for the position of the appliance, and clearance reduction may be possible with just changing to a listed double wall connector approved for use with the appliance and factory-built chimney or with connector protection.

Connector design may also be a draft consideration because of flow resistance. The most trouble free venting system will go straight up with no horizontal run or elbows. These create resistance to the flow of flue gases. According to IRC and NFPA, horizontal sections of chimney connector must have a minimum rise toward the chimney of ¼ inch per foot. IRC currently requires that a horizontal length of connector be no longer than 75% of the height of the vertical portion of the chimney above the connector. NFPA 211 requires that the horizontal run of a connector be no longer than 50% of the height of the vertical portion of the chimney above the connector for solid fuel appliances. Thus, an installation with 12 feet of vertical chimney – disregarding any vertical connector – could have a horizontal run up to 9 feet according to IRC, but only 6 feet according to NFPA 211. High efficiency woodstoves, however, require strong draft, an issue that may not be recognized in current codes and standards. Some manufacturers specifically limit total horizontal run and/or total length of connector pipe. The shorter the horizontal run the better the draft. A vertical chimney connector promotes the best possible draft and allows creosote and soot to fall back into the installation appliance to be burned. Although there is no universally accepted maximum connector length, NFPA 211 and IRC call for the connector to be "as short and straight as practical."

A chimney connector may never pass through a roof, ceiling, crawl space, wall, window, closet, or concealed area; for these situations, a complete, listed factory-built chimney or code approved masonry chimney is required. All components of the venting system past the union of connector and chimney must be chimney components. No further use of a chimney connector after this point is allowed. Chimney connector is either single, double, or for venting systems that bring combustion air directly to the appliance, triple wall sheet metal pipe.

5.2.1 Single Wall Connectors

Black steel is the most commonly used material for single wall chimney connector, although stainless steel is also acceptable. Chimney connectors may be painted with high temperature paint or may have a vitreous enamel finish. The thickness of sheet metal is expressed as a "gauge." Twenty four (24) gauge is approximately equivalent to .025 inch. The lower the gauge number, the thicker the metal. According to NFPA 211, twenty four (24) gauge chimney connector is the minimum thickness acceptable for 6 inch (or greater) diameter single wall chimney connector. Heavier gauge connectors are more durable and reliable.

The most common type of chimney connector, single wall black steel, may have welded or crimped seams and be available in 1 to 4 foot sections in 22 or 24 gauge metal. Stainless steel must be used as the unexposed connector in a wall pass through system.

According to most codes and solid fuel appliance listings, a single wall chimney connector must have at least an 18 inch clearance to combustible walls and ceilings. A few listed solid fuel appliances require more than 18 inches clearance for their chimney connector; others require less. As with appliances, single wall connector clearances may be reduced by shielding or protecting combustibles with approved clearance reduction methods. It is important to note that minimum clearances to combustibles in an installation must be met for both the appliance and the chimney connector. Since a top exit connector is often not flush with the back of the appliance, care must be taken in determining which component, appliance or connector, determines placement.

Similar to appliance clearance reductions, connector clearances cannot be reduced below those allowed in the table shown in NFPA 211 (Table III above). In no case shall the clearance between the connector and a wall surface be reduced below that allowed in the clearance reduction table. The smallest clearance in that table is 6 inches. The IRC clearance reduction table includes appliances, vent connectors, and single wall pipe, some of which have unprotected clearances as small as 6 inches. The IRC reduction table does not apply to listed chimney double wall connectors.

Serious chimney fires can cause the chimney connector to vibrate violently; unless the joints between sections of chimney connector are securely attached, the joints can break loose. All joints between sections of chimney connector should be secured with at least 3 sheet metal screws equally spaced around the circumference of the connector. In addition, the first section of chimney connector needs to be attached to the solid fuel appliance. This may require drilling the flue collar of the appliance.

Chimney connector reduced clearances with wall and ceiling protection
(assuming 18" required clearance to combustibles with no protection)

	Maximum clearance reduction (%)		Minimum allowable clearance (inches)	
Type of protection	**Wall**	**Ceiling**	**Wall**	**Ceiling**
3.5" thick masonry wall without ventilated airspace*	33%	–	12"	–
0.5" thick noncombustible insulation board over 1" glass fiber or mineral wool batts without ventilated airspace	50%	33%	9"	12"
24 gauge sheet metal over 1" glass fiber or mineral wood batts reinforced with wire, or equivalent, on rear face, with at least 1" ventilated airspace	66%	50%	6"	9"
3 1/2" thick masonry wall with at least 1" ventilated airspace	66%	–	6"	–
24 gauge sheet metal with at least 1" ventilated airspace	66%	50%	6"	9"
1/2" thick noncombustible insulation board with at least 1" ventilated airspace	66%	50%	6"	9"

* If a single wall chimney connector passes through this masonry wall, there must be 1/2" airspace between the chimney connector and the masonry.

5.2.2 Double Wall Connectors

Double wall connectors, usually constructed of an inner stainless steel pipe, an air space, and an outer black steel pipe, is either chosen to reduce connector clearances or required in certain installations, such as in mobile home appliance listings. It is important to determine whether the appliance manufacturer specifies specific brand(s) of double wall connector and chimney or allows any listed products. This is particularly important to insure safe heat dissipation at the ceiling union of connector and chimney.

Minimum listed clearance from double wall connector to a combustible surface is typically 6 inches, but various listed double wall chimney connectors may have different clearance requirements; it is therefore important to refer to each manufacturer's specifications.

Although NFPA 211 does not specifically prohibit further reduction of double wall connector listed clearances through use of the clearance reduction methods in Table III, it also does not specifically approve and define such reductions as it does with reduction of listed appliance clearances to combustibles. The position recommended here, therefore, is that chimney connector clearances may not be reduced to less than 6 inches from combustibles, and that double wall connectors can be installed closer than 6 inches to combustibles only if their listing with an appliance allows clearances to unprotected combustibles to be less than 6 inches.

Double wall connector cannot be cut to length like single wall. An adjustable section will almost always be required. All joints should be secured according to manufacturer's instructions. For some appliances, or for some applications such as mobile home installations, the double wall connector may require approval for use by the appliance manufacturer. The appliance manufacturer may require greater minimum clearances to combustibles than those specified by the connector manufacturer. Heat retained at the double wall connector level (normally dissipated through single wall connector) may raise firebox temperatures and cause excessive heat buildup on the floor level or elsewhere. When double wall connectors listed for use with a woodstove is used, minimum clearances for the appliance and for the double wall connector must be met or exceeded. If appliance manufacturer minimum clearances are greater than the double wall connector manufacturer minimum clearances, the appliance manufacturer clearances must be followed. Follow appliance manufacturer instructions carefully.

5.2 Chimney Connectors

Chimney connectors perform the important function of joining the appliance to the chimney. The most common use is with woodburning freestanding stoves. Connector pipes may also be used in some gas and pellet installation, although that is very rare. Factors concerning chimney connectors in installation planning include concerns about clearances, draft, and creosote accumulation. Connector clearance may be the determining factor for the position of the appliance, and clearance reduction may be possible with just changing to a listed double wall connector approved for use with the appliance and factory-built chimney or with connector protection.

Connector design may also be a draft consideration because of flow resistance. The most trouble free venting system will go straight up with no horizontal run or elbows. These create resistance to the flow of flue gases. According to IRC and NFPA, horizontal sections of chimney connector must have a minimum rise toward the chimney of ¼ inch per foot. IRC currently requires that a horizontal length of connector be no longer than 75% of the height of the vertical portion of the chimney above the connector. NFPA 211 requires that the horizontal run of a connector be no longer than 50% of the height of the vertical portion of the chimney above the connector for solid fuel appliances. Thus, an installation with 12 feet of vertical chimney – disregarding any vertical connector – could have a horizontal run up to 9 feet according to IRC, but only 6 feet according to NFPA 211. High efficiency woodstoves, however, require strong draft, an issue that may not be recognized in current codes and standards. Some manufacturers specifically limit total horizontal run and/or total length of connector pipe. The shorter the horizontal run the better the draft. A vertical chimney connector promotes the best possible draft and allows creosote and soot to fall back into the installation appliance to be burned. Although there is no universally accepted maximum connector length, NFPA 211 and IRC call for the connector to be "as short and straight as practical."

A chimney connector may never pass through a roof, ceiling, crawl space, wall, window, closet, or concealed area; for these situations, a complete, listed factory-built chimney or code approved masonry chimney is required. All components of the venting system past the union of connector and chimney must be chimney components. No further use of a chimney connector after this point is allowed. Chimney connector is either single, double, or for venting systems that bring combustion air directly to the appliance, triple wall sheet metal pipe.

5.2.1 Single Wall Connectors

Black steel is the most commonly used material for single wall chimney connector, although stainless steel is also acceptable. Chimney connectors may be painted with high temperature paint or may have a vitreous enamel finish. The thickness of sheet metal is expressed as a "gauge." Twenty four (24) gauge is approximately equivalent to .025 inch. The lower the gauge number, the thicker the metal. According to NFPA 211, twenty four (24) gauge chimney connector is the minimum thickness acceptable for 6 inch (or greater) diameter single wall chimney connector. Heavier gauge connectors are more durable and reliable.

The most common type of chimney connector, single wall black steel, may have welded or crimped seams and be available in 1 to 4 foot sections in 22 or 24 gauge metal. Stainless steel must be used as the unexposed connector in a wall pass through system.

According to most codes and solid fuel appliance listings, a single wall chimney connector must have at least an 18 inch clearance to combustible walls and ceilings. A few listed solid fuel appliances require more than 18 inches clearance for their chimney connector; others require less. As with appliances, single wall connector clearances may be reduced by shielding or protecting combustibles with approved clearance reduction methods. It is important to note that minimum clearances to combustibles in an installation must be met for both the appliance and the chimney connector. Since a top exit connector is often not flush with the back of the appliance, care must be taken in determining which component, appliance or connector, determines placement.

Similar to appliance clearance reductions, connector clearances cannot be reduced below those allowed in the table shown in NFPA 211 (Table III above). In no case shall the clearance between the connector and a wall surface be reduced below that allowed in the clearance reduction table. The smallest clearance in that table is 6 inches. The IRC clearance reduction table includes appliances, vent connectors, and single wall pipe, some of which have unprotected clearances as small as 6 inches. The IRC reduction table does not apply to listed chimney double wall connectors.

Serious chimney fires can cause the chimney connector to vibrate violently; unless the joints between sections of chimney connector are securely attached, the joints can break loose. All joints between sections of chimney connector should be secured with at least 3 sheet metal screws equally spaced around the circumference of the connector. In addition, the first section of chimney connector needs to be attached to the solid fuel appliance. This may require drilling the flue collar of the appliance.

Chimney connector reduced clearances with wall and ceiling protection
(assuming 18" required clearance to combustibles with no protection)

	Maximum clearance reduction (%)		Minimum allowable clearance (inches)	
Type of protection	**Wall**	**Ceiling**	**Wall**	**Ceiling**
3.5" thick masonry wall without ventilated airspace*	33%	–	12"	–
0.5" thick noncombustible insulation board over 1" glass fiber or mineral wool batts without ventilated airspace	50%	33%	9"	12"
24 gauge sheet metal over 1" glass fiber or mineral wood batts reinforced with wire, or equivalent, on rear face, with at least 1" ventilated airspace	66%	50%	6"	9"
3 1/2" thick masonry wall with at least 1" ventilated airspace	66%	–	6"	–
24 gauge sheet metal with at least 1" ventilated airspace	66%	50%	6"	9"
1/2" thick noncombustible insulation board with at least 1" ventilated airspace	66%	50%	6"	9"

* If a single wall chimney connector passes through this masonry wall, there must be 1/2" airspace between the chimney connector and the masonry.

5.2.2 Double Wall Connectors

Double wall connectors, usually constructed of an inner stainless steel pipe, an air space, and an outer black steel pipe, is either chosen to reduce connector clearances or required in certain installations, such as in mobile home appliance listings. It is important to determine whether the appliance manufacturer specifies specific brand(s) of double wall connector and chimney or allows any listed products. This is particularly important to insure safe heat dissipation at the ceiling union of connector and chimney.

Minimum listed clearance from double wall connector to a combustible surface is typically 6 inches, but various listed double wall chimney connectors may have different clearance requirements; it is therefore important to refer to each manufacturer's specifications.

Although NFPA 211 does not specifically prohibit further reduction of double wall connector listed clearances through use of the clearance reduction methods in Table III, it also does not specifically approve and define such reductions as it does with reduction of listed appliance clearances to combustibles. The position recommended here, therefore, is that chimney connector clearances may not be reduced to less than 6 inches from combustibles, and that double wall connectors can be installed closer than 6 inches to combustibles only if their listing with an appliance allows clearances to unprotected combustibles to be less than 6 inches.

Double wall connector cannot be cut to length like single wall. An adjustable section will almost always be required. All joints should be secured according to manufacturer's instructions. For some appliances, or for some applications such as mobile home installations, the double wall connector may require approval for use by the appliance manufacturer. The appliance manufacturer may require greater minimum clearances to combustibles than those specified by the connector manufacturer. Heat retained at the double wall connector level (normally dissipated through single wall connector) may raise firebox temperatures and cause excessive heat buildup on the floor level or elsewhere. When double wall connectors listed for use with a woodstove is used, minimum clearances for the appliance and for the double wall connector must be met or exceeded. If appliance manufacturer minimum clearances are greater than the double wall connector manufacturer minimum clearances, the appliance manufacturer clearances must be followed. Follow appliance manufacturer instructions carefully.

Chapter 6 Installation Planning

Preparation for installing a hearth system starts with the manufacturer's instructions and local code requirements. It is important to make sure that the instructions are current, since models and instructions change. Failure to understand and follow manufacturer's instructions and local code requirements can result in damage to property, legal liability, and loss of life.

The most important principle in installation centers on a clear understanding of combustible materials and how they can ignite without the presence of flame. That understanding, and the knowledge that over time the ignition temperature of combustibles may become lower, underscores the importance of rigid, unfailing adherence to meeting or exceeding minimum required clearances.

6.1 Combustibles

The first step in planning a fireplace or woodstove installation is understanding heat transfer and ignition of combustibles. That understanding should make clear the critical importance of strict adherence to installation instructions.

A combustible material is one that is capable of igniting or burning. A noncombustible material is defined as that which will not ignite or burn when subjected to flame or intense heat for long periods of time.

6.1.1 Framing, Walls, and Ceilings

Materials consisting entirely of metal, brick, tile, concrete, slate, asbestos, or plaster, or any combination thereof, are noncombustible. Plaster on metal lath and on metal studs is considered noncombustible.

All walls containing wood framing or paper faced materials are combustible. This includes plaster on wood lath or wood studs, and gypsum board (sheetrock/drywall) on wood OR metal studs. Some paperless types of drywall/sheetrock have fiberglass backing and are considered noncombustible. **NOTE:** Even fire rated drywall/sheetrock that has paper covering must be treated as a combustible material because of its paper facing. Nearly every wall and ceiling in residential buildings contains wood or paper faced materials. A noncombustible facing material such as brick may conceal combustibles. If there is uncertainty as to the construction of a wall or ceiling, it is best to assume it is combustible and maintain proper clearances for combustible materials.

Drywall

The very common building product, drywall/sheetrock, has undergone some product and code changes that merit attention. Until recent years, all drywall/sheetrock was considered combustible because of its paper covering, including those that are fire rated. The advent of drywall faced with fiberglass made this particular version of the product an exception that could be considered noncombustible.

The 2012 edition of IRC, however, now specifically mentions gypsum board as a combustible material. Without a distinction regarding the board coating, it may be advisable to treat all drywall/sheetrock as combustible.

There are two important considerations when planning the venting system's route through the ceiling and/or through the wall. First, many homes are constructed with engineered trusses. Trusses are never to be cut or modified in any way. If the installation cannot be completed and minimum clearances are satisfied, you must look for another option. That may include a different appliance, a different location for the appliance or a different venting method. Second, don't forget to take into consideration the width of the standard construction lumber. Normally, 2x4s or 2x6s are laid either 16" on center or 24" on center. The nominal width of a 2x4 or a 2x6 is 1½". Consequently, that wall that is built 16" on center only has 14½" between the two studs or rafters.

6.1.2 Floors

A floor is considered noncombustible if it is concrete slab-on-grade or solid concrete with exclusively steel or concrete supports. If there are any combustibles beneath a noncombustible floor or hearth extension, adequate protection must be provided according to code and/or manufacturer's specifications. All wood floors, carpets, and synthetic flooring materials over wood floors or joists are considered combustible and must be protected in an approved manner. If the materials are questionable or not readily visible for inspection, they should be treated as combustibles, or an appropriate inspection should be called for.

6.1.3 Heat Transfer

It is essential to understand how heat transfers to and affects combustible objects. Heat is transferred by radiation, waves of energy that become heat when they strike a solid object; convection, the movement of heated air; and conduction, the direct transfer of heat between solid objects. The burning fuel radiates and convects heat that is conducted through the walls of the appliance. In turn, the heat radiates from the appliance walls, warming solid objects in the path of the radiant energy. Air is warmed by passing over the surfaces of the system and other warmed solid objects. The warmed air transfers heat by convection. This process is often helped by the addition of a blower on the appliance. Heat is transferred from the walls of the chimney connector and chimney, as well as from the appliance.

The radiant transfer of heat is a critical factor affecting combustibles. As waves of radiant energy strike a combustible object, heat is absorbed and the temperature of the object is raised. Radiant heat absorbed by a noncombustible material can also transfer through the material to adjacent combustibles. When the ignition temperature of the combustible object is reached, it will ignite, without any direct contact with flame.

The ignition temperature of combustibles varies both with materials and their condition. With drying out over time, many materials can ignite at significantly lower temperatures than when new or first installed. Research that formed the basis of safety standard testing indicated that wood products begin to degrade with long term exposure to 250°F. Ignition of wood products can occur with long term exposure to temperatures as low as 300 – 400°F with no exposure to flame. For adequate safety margin, against both degradation that can affect structural properties and lowered ignition temperatures that can result in fire, maximum temperatures required in UL 1482 Solid Fuel Type Room Heaters testing are under 212°F.

The danger of radiant heat transfer becomes especially critical when combustibles are concealed, such as in chimney wall penetrations, unknown wall construction behind noncombustible facing, and combustibles beneath appliances and hearth extensions or in areas not in normal view, such as in attics and chimney enclosures. As these combustibles dry out and change with time and exposure to heat, the amount of heat needed to ignite them becomes less and less. They may even be visibly scorched, but their location prevents detection. If the heat source is close enough and hot enough, these materials will ignite and may not be noticed in time to be extinguished safely. The degradation of combustible materials in proximity to the solid fuel appliance, chimney connector, or chimney may take years to occur and is the reason and determining limits behind the clearance requirements in most industry codes and standards.

6.2 Clearances

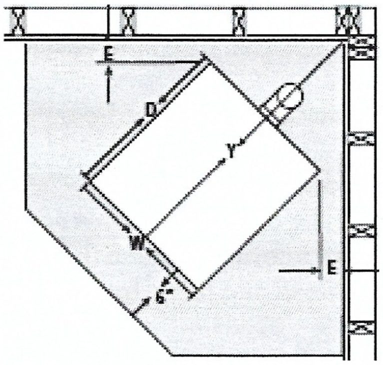
The first consideration in placement is usually making sure that the appliance is a safe distance from combustible materials. The manufacturer's installation instructions usually provide a chart showing minimum clearances from the front, side, back, and corners of the appliance. While clearances are vitally important when a hearth appliance is first installed, they become even more important years down the road. As a combustible material is exposed to heat over a long period of time, the ignition temperature of that material lowers due to pyrolysis. The ignition temperature of wood is about 450 degrees. After several years, the ignition temperature may be lowered to 300 degree or less.

Besides the possibility of noticeably warm surfaces that may disturb owners, it is almost always advisable to place the appliance with maintenance and service in mind. This may necessitate disconnecting and moving the appliance for maintenance or repairs. Access to the vent connection and/or cleanout, control board, motor access panels, and the like should be considered whenever possible. Easy access to controls for operation can also be a matter of concern in some installations.

Installation in an alcove (a recessed, partially enclosed extension of a room) must be considered carefully. Some manufacturers define the minimum depth, width, and height of an acceptable alcove installation. NFPA 211 prohibits solid fuel appliances from being installed in alcoves or enclosed spaces less than 512 cubic feet.24 Again, consideration should be given to convenient access for operation, fuel loading, and maintenance. If the appliance has not been tested and listed for such installations, avoid these enclosures that might result in hazardous heat build-up.

Finally, positioning the appliance safely may be determined not by appliance clearances, but instead by venting clearances. For instance, the clearance for a tee behind the appliance may not be met if the appliance were positioned according to appliance minimum clearances. It is important in planning to consider all clearance requirements carefully, and in installation to check them again.

Clearance is a defined space between a heat producing surface (appliance, chimney connector, or chimney) and a combustible material. The space may be defined as an air space with no intervening materials, even noncombustible ones, or it may specify noncombustible materials and their position in the space. Maintaining proper clearances to combustibles is the most important consideration for safe installations. Clearances for listed appliances can vary from a few inches to 36 inches or more. The proper minimum clearance depends on design and construction, and is determined through testing for listed appliances, chimney connector, and chimney systems. It should be noted that testing standards may allow temperatures of combustibles to be noticeably warm to the touch, and it may be worthwhile to advise customers who choose minimum clearance installations. When manufacturers conduct safety testing, minimum clearances are determined by the minimum distance measured between a heat producing surface of the appliance to a combustible material. However, some manufacturers adjust printed version of the required clearances to measure from the top, side or legs of the appliance. Installation in accordance with manufacturer specifications and local code is imperative.



6.2.1 Corner Installations

Calculating the size of floor protection in a corner installation is simplified by use of the following formula to determine the distance from the corner of the room to the front of the appliance:

The formula therefore means:

The distance from the corner to the front of the appliance (Y) equals the rear corner clearance (E) multiplied by 1.414 (the square root of 2, a constant that comes from calculating the hypotenuse of a right triangle); for our purposes, a number you plug in) plus the stove width divided by 2 (W/2) plus the depth of the stove (D).

Y = E x 1.414 + W/2 + D

Where

Y = distance from corner to front of the appliance

E = clearance from rear corner of appliance to wall

1.414 = a constant

W = appliance width

D = appliance depth

When the distance from the corner to the front of the appliance is determined, the required floor protection extension is added to determine the minimum distance from the corner to the edge of the floor protector. For example, an appliance 26 inches wide by 26 inches deep with a 4 inch clearance to the corner would be calculated:

Y = 4 x 1.414 + 26/2 + 26

Y = 5.656 + 13 + 26

Y= 44. 656, rounded up to 45 inches from the corner to the front of the appliance.

If the floor protection requirements call for an extension of 6 inches in front of the appliance, the front edge of the floor protection must be at least 45 + 6 = 51 inches from the corner.

6.3 Appliance Installation Planning

Installation has many meanings with regard to hearth appliances. It may mean setting up a new appliance in an existing site, where to code compliant floor protection, wall protection, and chimney are in place, and all clearance requirements of the new appliance are met. It may mean having to prepare the site and install the entire system.

It may be relatively straight forward, or it may be extremely complicated. Planning the installation may involve working with the customer in selecting an appropriate appliance and the many details involved in getting the system installed according to the customer's wishes. There may be no contact with the end user at all. Whatever the case, it is important to first prepare by being totally familiar with local code requirements and the manufacturers' installation instructions for all products to be installed.

Considering as many factors that affect appliance placement in the planning phase of installation as possible can prevent unpleasant surprises. Placement concerns beside clearances and floor protection include:

- **Venting obstructions.** Determine whether there are problems with the venting route, including framing, wiring, and ductwork. Some framing cannot be cut or altered, including engineered trusses. Moving the appliance or planning an offset may be necessary.
- **Outside air.** If required or desired, outside air connections must be made according to manufacturer's instructions and applicable codes. Outside air should be drawn from an approved, ventilated source.
- **Electrical Outlet.** Be sure an outlet that has proper grounding, polarity, and voltage is available in the immediate vicinity of the appliance. Some manufacturer's call for the circuit to serve only the pellet appliance or for the delivered voltage to be within prescribed limits.
- **Wall Thermostat.** If the appliance is to be controlled by a remote thermostat, be sure that the thermostat can be placed appropriately for temperature sensing and for wiring to the appliance. Consideration should also be given with regard to the wall thermostat of a central furnace, particularly to avoid problems from the appliance and thermostat being too close together. Locate the thermostat on an interior wall away from direct heat flow from the appliance or from furnace registers, lamps, and other heat sources. Also locate away from sources of cold drafts, such as windows. Mount the thermostat level and plumb, usually about 5 feet above the floor.
- **Heat Distribution.** Checking room size, openings, and airflow can help establish realistic owner expectations. Careful consideration must be given to whether proper air flow and heat distribution are possible.

NFPA 211 and IRC have requirements for the exterior inlet of the combustion air duct. NFPA 211 specifies that the inlet must **not** originate in:

- An attic
- A basement
- A garage
- Another interior space

- **Traffic Patterns.** Try to avoid placing the appliance in the line of heavily used passageways to minimize accidental contact with the appliance. Heavy traffic areas or areas close to doors that open and close often can cause safety vacuum sensors to trip unexpectedly and proper balancing may be impossible.
- **Room Use/Size.** Manufacturers or code regulations may prohibit the installation of a pellet appliance in a bedroom or in an enclosed space or alcove below a minimum volume.

During the sales and planning process, a good deal of information has to be gathered in order to end up with a hearth system that is appropriate for the customer's needs and desires. Some of that information can be obtained in conversation, while some of it may require viewing of building plans and/or a site visit. An important area of information, one that is not always easy to get, is the customers' reason for their purchase. The range of purposes can be broad and fuzzy, but they generally include:

- **Recreation and ambiance:** the fun, atmosphere, romance, tradition, design enhancement of the hearth
- **Zone heating:** a limited area, usually remote from the main living area or an addition that has inadequate heat
- **Primary heat source:** for economy, comfort, lifestyle choice, and other reasons
- **Back up emergency heating:** for power outages, either a limited area or the ability to furnish primary heat when desired.

Most retailers find it important not only to try to match customer purpose with appliance choice, but also to use the sales and planning period to help establish realistic expectations. Customers who are pleasantly surprised by their hearth system are the best sources of word of mouth references. Both appliance selection and installation planning depend heavily on where the system will be installed. For new construction, the planning details may involve timing and working with other contractors. The choice of appliance may be wider for new construction than as an existing home remodel. For existing homes, an existing chimney or hearth may have to be evaluated for use with a new appliance.

Appliance location reflects the objectives and preferences of the homeowner. For ease of monitoring and refueling as well as for aesthetic enjoyment, appliances are ideally placed in frequently used areas such as the living room, family room, or den.

Installation planning details include making sure clearances can be met or exceeded. Minimum clearances between the firebox and framing, papered sheetrock, and other combustibles must be maintained.

The same is true for the area surrounding the chimney and for its penetration of walls, ceilings, floors, and roofs. The fireplace should also be located so that appropriate minimum clearances between the fireplace and adjacent walls and other combustibles (such as drapes and furniture) will be maintained. Consult the manufacturer's instructions for this specification. This spacing is required to prevent hazardous overheating of combustible materials by heat radiated from the fireplace opening.

Some manufacturers offer shielding accessories or recommend materials that allow their fireplaces to be installed at reduced clearances. These reduced clearances are normally included in the manufacturer's installation instructions. Check manufacturer's instructions for any requirements for the minimum size of the room where the fireplace is to be located. The fireplace should not be located in an area where flammable liquids or gases will be used or stored. The fireplace should not be located near frequently opened doors, central heat furnace outlet registers or cold air returns or in any area where turbulence or negative pressure effects will create air movement that will cause smoke spillage, or allow flames, sparks, or ashes to escape the fireplace opening. Do not place the fireplace directly across from, or in an area where its heat output will affect central heating thermostats.

6.3.1 Factory-built Fireplaces

Its light weight and close clearance to combustibles capability makes the factory-built fireplace an extremely versatile hearth product. Because of their relatively small framing dimensions, factory-built fireplaces may be placed in corners, against interior and exterior walls, used as room dividers, or installed in field constructed chases on the exterior of a dwelling.

Additionally, factory-built fireplaces do not require special footings and foundations because they generally weigh no more than a large piece of furniture. Sufficient care should be taken; however, to make sure that floor joists and/or the foundation for the fireplace are strong enough to support the fireplace system without sagging for the expected life cycle of the building in which it is placed. Part of the sizing decision for fireplaces may depend on aesthetic design choices. In spite of the many installation conveniences of factory-built fireplaces, there are factors that affect safety, performance, and installation cost that should be considered.

An attempt to make masonry fireplaces more efficient was with the use of a steel firebox with a damper surrounded by an air chamber and second steel wall, enclosed in at least 8 inches of solid masonry were very popular from 1960-1980 as they eliminated the need for a trained mason to build sloping firebox walls. However, home owners often confuse these fireplaces with factory-built fireplaces. Some popular brands were Heatilator and Superior. Superior had a model called the Heatform®, which along with Heatilator became generic terms used to describe steel-lined masonry fireplaces. However, there were also other manufacturers of these units.

Factory-built fireplaces are designed and built as a complete system. Every component from the hearth to the rain cap is included in the safety listing. Replacement parts and accessories must be listed components. Since so many fireplace manufacturers have gone out of business making listed replacement parts or accessories impossible to provide, a petition was sent to NFPA to allow non-listed parts or accessories. The 2016 edition of NFPA 211 includes the following statement:

14.7.1.2 Factory-built fireplace components or accessories shall be listed or approved for use with the specific model of factory-built fireplace system if the components or accessories are available.

14.7.1.2.1 If original manufacturer's listed components or accessories are unavailable, components or accessories acceptable to and installed by a qualified agency shall be installed in accordance with the component or accessory manufacturer's installation instructions.

6.3.1.1 Clearances and Framing Dimensions

Minimum framing dimensions must be followed very carefully. Particular attention should be paid to minimum height. The manufacturer may provide a diagram with appliance dimensions, another drawing and chart for minimum clearances, and yet another set of instructions for floor protection. Additional shielding may be required. The instructions for floor protection may include an air space or a component that incorporates an air space below the appliance. If so, the height of the framed opening must be at least the total of the air space below the appliance, the height of the appliance, and the minimum clearance to combustibles above the appliance. If no air space is required below the insert, be sure to consider framing height from the top of the floor protector to the combustible framing above the insert. Clearances for the venting must also be considered. Outside air access may need to be considered in planning framing. Metal standoffs are often installed on factory-built fireplaces that help ensure minimum clearances to combustibles are met. Be sure the framing dimensions allow for the standoffs. They should not be removed or bent in any fashion.

6.3.2 Freestanding Stoves

It is important for both safety and comfort that freestanding stoves be sized properly to heat the intended space. If an appliance is much too large, it cannot be operated in its optimum burn range in any but the coldest weather conditions. Oversized solid-fuel appliances were particularly problematic when operated for the majority of the heating season in a slow burn; air starved, and creosote producing fashion. EPA appliance design alleviates the problem of over sizing somewhat, but sensible sizing (including taking into account factors such as climate and intended use/heating objectives, and house insulation/tightness) and user understanding of adjusting fuel loads to weather conditions are still important factors. For customers and for milder climates where operation at low burn rates is expected, it may be worth considering appliances with a wider range of turn down rates that deliver effective burns. Lack of attention to these factors may result in lower combustion efficiencies, greater emissions, higher rates of creosote and moisture accumulation, and customer dissatisfaction. It is generally preferable to "err" by under rather than over sizing an appliance. Occasionally, if an appliance is significantly undersized, however, over fire/overheat conditions may cause premature failure of the appliance. Discoloration of the finish, warpage, or cracking within the appliance is indicators of over firing.

6.3.2.1 Stove Location

Clearances to combustibles are often the first consideration in planning freestanding stove installations. Walls and floors, mantle and trim, and furniture are some of the combustibles that must be taken into consideration. Floor protection, both size and materials are important considerations. Traffic patterns in the room may also need to be taken into consideration, particularly for freestanding stoves. If the objective is to heat more than the room in which the appliance is located, centrally located stoves usually heat the greatest area of the home with the greatest comfort. Size of the room and heat distribution factors such as doorways, stairwells, and forced air distribution may also be considered. The location of the central heating thermostat can be a factor worth considering. Some considerations that affect operation and maintenance that may affect installation planning include:

- Appliance features such as loading door location and ash removal systems
- Ease of performing maintenance activities
- Space for safe and convenient fuel storage (wood or pellets)

The location selected should require minimal cutting of joists and rafters, and limited alteration of the dwelling structure.

6.3.2.2 Planner's Recommendations

Precise sizing is unrealistic given the variables of fuel (for woodburning), climate, weather, home construction, and user desires and skills. Nonetheless, understanding sizing considerations and clues prevents avoidable errors. Manufacturer supplied guidelines may be a source for misunderstanding. The numbers, usually in square feet or number of rooms, are subject to broad interpretation. The numbers may be confusing or inaccurate if assumptions are made about ceiling height, varying home insulation and weatherization factors, climate, comfort level, and customer expectations. The disparity between manufacturer recommendations for similar size and BTU output units is a source of confusion for customers that often needs explaining.

The confusing numbers and variables mean that clear communication with prospective stove owners is essential. The factors that may need to be explained and discussed include:

- The area to be heated in cubic feet.
- Insulation values in ceilings, walls, and floors.
- Air infiltration. What is the age of the home and condition of the structure: is it tight, with good weather stripping?
- Window size, quantity, condition, and location. If numerous large windows and/or patio doors are present (exceeding 15% of wall space), heat loss may be significant. Double or triple glazed windows combat some of this heat loss. Exposure to northerly directions may mean greater heat loss.
- The space configuration of the structure. Is it open or partitioned off into many small rooms? Are areas separated from the appliance by barriers, great distances, and turns that prevent air flow?
- Are there nonstandard (above eight feet) ceilings? If so, are there low speed ceiling fans?
- Customer expectations. Is the appliance to be a primary, secondary, or recreational heat source? How does the customer describe comfortable heating levels?

Other factors to take into account include local climate and wind conditions, solar heating gain, and frequency of door openings (with children, for example). In addition to all of these factors, heat loss calculations, if available from the dwelling's mechanical specifications, may be of help. Conventional heating system rated outputs are another source of information. Often the final selection of the size of the appliance is determined successfully by the dealer's knowledge of the appliance's capability through experience, combined with clear communication with the prospective owners.

BTU ratings: Where the numbers came from

Efficiency. The EPA numbers did not represent testing of each model and brand. Instead, the hang tag efficiency rating is a generic, default efficiency for the type of combustion system: 72% for catalytic appliances and 63% for non-catalytic. Some manufacturers have had their appliances tested for efficiency by independent testing laboratories. Under current NSPS proposals, all EPA Certified appliances will undergo standardized efficiency testing and reporting.

An efficiency rating published in the appliance manufacturer's literature usually reflected a higher than the EPA default efficiency. Such efficiency testing methods were not standardized and may have reflected different definitions and methods of testing efficiency. There will certainly be some confusion of terms and numbers, but the intent of current NSPS proposals appears to be more consistency and reliability in testing procedures and reporting.

Heat Output. The high heat output range on the EPA hang tag has been a measure of BTUs produced from a single load of fuel, with the appliance air controls set at the maximum level. It is important to understand that the appliance was not reloaded during this test, and the test continued until the fire burns down to a specified amount of coals. The total number of BTUs produced during this burn time were divided by the length of time of the burn to calculate the "high heat output." This test protocol resulted in confusing numbers: an appliance with a much larger firebox might have an EPA high output rating lower than a small appliance. This resulted from the longer length of the burn (until a certain amount of coals remain) for the larger appliance.

Maximum BTU output differs from high BTU output. Maximum heat output is a measure of the highest amount of heat that can be safely generated on a sustained basis. Appliances tested by manufacturers for maximum heat output are typically reloaded frequently, simulating the homeowner's operation to produce a considerable amount of heat. Again, testing methods have not been standardized and have varied from manufacturer to manufacturer, which may change with time and NSPS requirements.

6.3.3 Fireplace Inserts

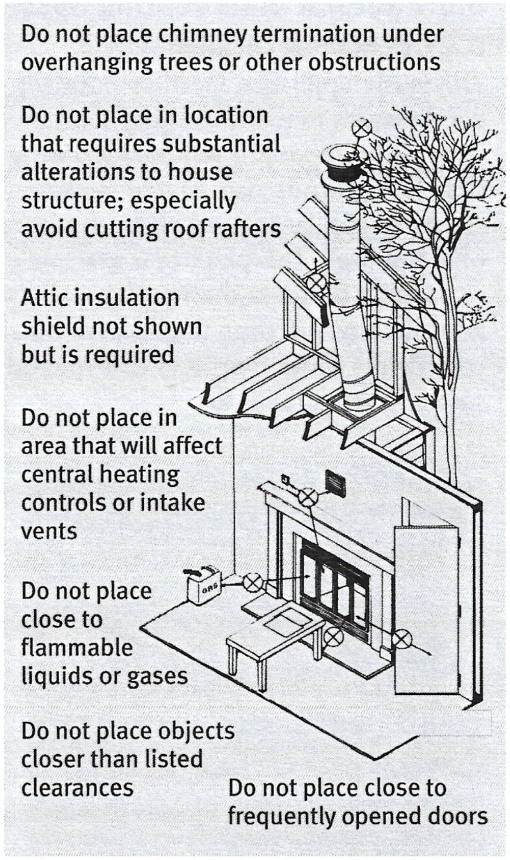
Placement is usually predetermined by the location of an existing fireplace. Planning the insert installation is therefore a process of making sure that the fireplace is appropriate for an insert and that the insert fits properly in the opening, meets clearances to combustibles, has adequate floor protection, proper power supply, and reasonable maintenance considerations.

6.3.3.1 Fireplace Dimensions and Condition

The fireplace should be checked carefully to verify its appropriateness for a pellet insert. Minimum fireplace dimensions should be reviewed carefully, particularly with factory-built fireplaces, which may require larger dimensions than for masonry fireplaces.

Check width and height of the opening first to be sure that it is large enough to accommodate the unit.

Then check these dimensions again to be sure that the insert's surrounding panel will cover the gap between the unit and the face brick according to the manufacturer's instructions. If there are stepped out brick or protruding materials such as stone on the face of the fireplace, make sure the panel will fit and seal properly.


Do not place chimney termination under overhanging trees or other obstructions
Do not place in location that requires substantial alterations to house structure; especially avoid cutting roof rafters
Attic insulation shield not shown but is required
Do not place in area that will affect central heating controls or intake vents
Do not place close to flammable liquids or gases
Do not place objects closer than listed clearances
Do not place close to frequently opened doors

Next check the depth of the fireplace (from the face brick to the back of the fireplace) in two places: on the floor of the fireplace and at the height of the unit. The second depth check assures that an inward curving fireplace back does not interfere with the unit.

Note the amount of hearth extension into the room and its height.

Masonry fireplaces should be checked for structural soundness and adherence to code, such as NFPA 211/IRC, are general criteria for proper fireplace condition.

Factory-built fireplaces, also known as zero clearance or pre-fab fireplaces, should be checked for proper installation according to manufacturer's instructions. Extreme caution should be taken regarding the face of the fireplace. Openings or vents on the front of some fireplaces bring in air to cool the firebox and/or chimney that is essential for safe minimum clearances. These openings must not be blocked by the insert panels. Instructions for installation in a factory-built fireplace typically include language for a label that must be attached to the fireplace indicating that it has been altered to accommodate a fireplace insert and should be inspected before reuse as a fireplace.

A second area of concern regards the safety listing when installing a wood-burning fireplace insert in a factory-built fireplace. NFPA 211 prohibits a solid fuel-burning appliance using the flue of a factory-built fireplace unless it is specifically listed for such installation. It specifies that "a fireplace insert or heat exchanger, installed using an existing flue serving a factory-built fireplace be listed for use with a specific model factory-built fireplace." It is advisable to consult with manufacturers of the factory-built fireplace, the fireplace insert and the authority having jurisdiction concerning an acceptable safety listing. Some manufacturers require or recommend full relining for pellet inserts installed in a factory-built fireplace.

It is helpful to note whether the hearth (fireplace floor) drops down from the hearth extension. In some cases a noncombustible shim must to be used because the appliance does not have leveling bolts. Irregular hearth extension materials such as stone should also be noted. Close attention should be paid to the fireplace throat to plan a properly sealed block-off, or make sure that the surrounding panel is sealed, if required, according to manufacturer's instructions to prevent the chimney from becoming a source of make-up air in a tight home. The fireplace and chimney should be thoroughly cleaned to avoid materials being blown into the house by the convection blower. A number of manufacturers recommend painting the interior of the fireplace to seal off soot completely.

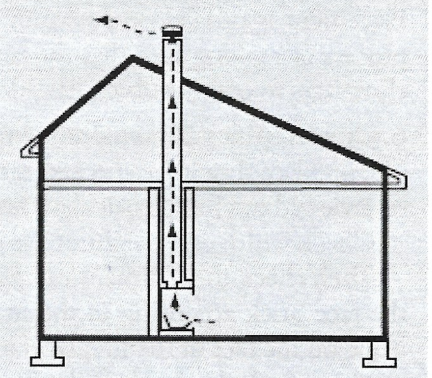
6.3.4 Natural Draft Chimney Location

Natural draft chimneys should be located so that it is as vertical as possible for maximum draft (and cost reduction). An interior location offers better draft performance than an exterior chimney location due to reduced heat loss from the chimney. The chimney should not terminate under overhanging trees or other obstructions that might create air turbulence that could reduce draft. The location selected should require minimal cutting of joists and rafters, and limited alteration of the dwelling structure.

6.4 Venting System Requirements

Customers understandably focus on the appliance and usually actively participate in decisions about its type, size, style, and location. The same is usually not true about the venting system. Other than a concern about appearance and cost, most customers regard the chimney as about as interesting as the tires on their new car. These circumstances – and the crucial importance for hearth system performance and safety – increase the responsibility of the hearth planner and installer to make sure that the details of the venting system that we examine here are carefully planned and carried out. Venting system problems are too difficult and expensive not to make a strong effort at preventive planning and education of customers.

Interior location: good draft



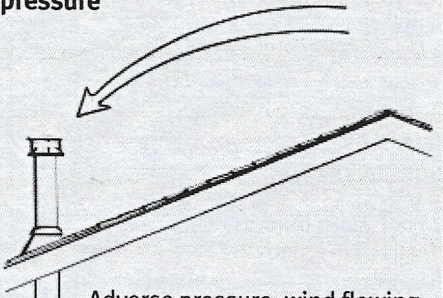
6.4.1 Natural Draft Venting Systems

6.4.1.1 Chimney Location

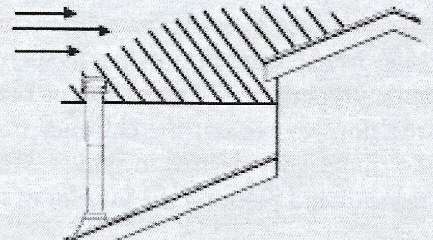
Obviously appliance location normally dictates chimney location, but there are good reasons to make chimney location a first consideration. During the planning stage these important venting location practices should be followed whenever possible for optimum natural draft and system performance:

Install appliances and chimneys inside the building envelope (heated portion of the house). This practice is extremely important in keeping flue gases as warm as possible for good draft and to prevent cold hearth syndrome when the system is at standby. Locating fireplaces in outside chases is considered the main cause of complaints about fireplaces that spill odors and cold air when not in use and that smoke when a fire is lit.

Effects of wind on venting adverse pressure

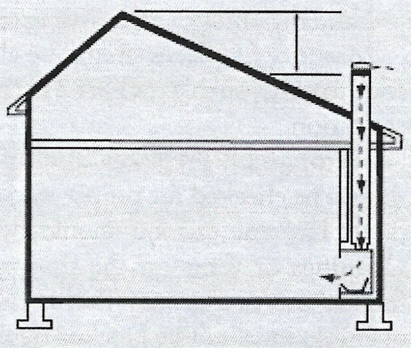


Adverse pressure: wind flowing over object and down towards chimney that inhibits draft



Adverse pressure: wind against building can cause positive pressure that restricts draft at top of chimney

Exterior location: spillage



Design the chimney to penetrate the building envelope at or near its highest level. The chimney should be as taller than the highest part of the building envelope in order to overcome the negative pressure that results from house stack effect.

The practicalities of roof design usually make following this practice another reason for an interior wall location for the appliance and chimney. If the appliance is on an exterior wall as in the bottom illustration on the previous page, having the chimney exceed the highest part of the heated building envelope means a very tall, hard to stabilize, unattractive chimney exposure above the roof. It also means that a large portion of the chimney is exposed to cold temperatures and at a distance from the heat source. An interior wall location is a greatly preferred location for appearance and performance.

Locate the chimney top above areas of wind turbulence. Another height consideration that affects chimney location is wind turbulence. The height and proximity of adjacent roof, other structures, and trees should be taken into account in selecting appliance and chimney location. Again, location on an exterior wall can result in another condition adverse to draft and performance. Chimneys low on the roofline are more prone to the effects of wind turbulence than a centrally located chimney near the roof peak. The chimney should always be supported above the roof according to the requirements in the chimney installation instructions.

6.4.1.2 Maximum Air Leakage Rates

This requirement sets the maximum air leakage based on climate regions of the country. For Zones 1 and 2 (the southern most parts of some southern and one western state) at an air leakage rate not exceeding 5 ACH50. For Zones 3 through 8 (the rest of the country) the rate must not exceed 3 ACH50.

As the 2012 edition of the IRC is adopted over time, the impact of energy efficiency requirements on residential construction and related industries will become apparent. Those requirements include increased insulation, better windows, tighter ductwork, and tighter construction. That tighter construction will revolve around the change from voluntary 7 ACH50 to mandatory, verifiable maximum 3 ACH50 for new homes in most regions of the United States that have not had such energy efficiency requirements.

In order to achieve such low air leakage rates, new construction will focus on the air barrier for the home. Air barrier products include house wraps that function as air and moisture barriers, closed cell spray polyurethane foam, and board stock, such as plywood or oriented strand board (OSB), and extruded polystyrene. This will mean that not only hearth products that require outdoor air for combustion will be a concern in very tight residential construction, but also any hearth system that penetrates the air barrier will impact the leakage rate of the home.

For hearth appliances, the first concern may be ensuring installation in a space that provides the required volume to ensure adequate combustion air. That may be difficult given the provisions in IRC and NFPA 211 that either reference the appliance manufacturer's instructions or call for adequate combustion air. This may mean that it will be necessary to consult with the manufacturer regarding installation recommendations in tight construction, including instructions for any sealing of the vent system penetrations of the air barrier. The concern for spillage in a negative pressure environment may rule out open chamber hearth appliances.

Finally, construction of a chase must be concerned with maximum air tightness. That may include extending the air barrier around the outside walls of the chase and sealing any penetrations such as vent termination or outside air kit according to instructions, drywall with tape or an equivalent method for the interior, as well as sealing of the perimeter of the fireplace to the surrounding wall according to the manufacturer's instructions. Local code must also be followed in the process.

Chapter 7 Safety Guidelines

The emphasis on safety to this point has been primarily on ensuring that the hearth system poses no safety threat to the owner and family that will enjoy the comfort and beauty of the system. Through knowledge of safety concerns, proper tools and techniques, and constant vigilance, the installers or service personnel can not only reap financial rewards and gain personal satisfaction from their work, they can also return unharmed to their own families at the end of the day.

There are a number of job safety information resources. If your company is subject to US Occupational Safety & Health Administration (OSHA) regulations, be sure to comply closely with them.

7.1 Personal Safety

Guidelines that should be followed carefully every day on the job include:

- Use eye protection
- Use ear protection
- Wear hard hats according to work site rules and in situations where objects may fall from above, where workers might bump their heads against fixed object such as exposed pipes or beams, or where there is a possibility of accidental head contact with electrical hazards.
    - Select the proper class hard hat (depending on whether and how much electrical shock protection is needed) and the proper size.
- Wear required or recommended foot protection such as footwear with toe caps or steel shanks.
- Use mask/respirator when cutting hazardous materials such as ceramic fiber or when handling fiberglass insulation, or when the potential is likely for coming into contact with creosote, animal debris, or harmful chemicals
    - Use filter material appropriate for material's potential contaminant/hazard
    - Store mask/respirator in airtight container when not in use to avoid dislodging and spreading contaminants
- Avoid skin contact with creosote
- Wear gloves for protection from sharp edges
- Exercise caution around hot surfaces, including stove surfaces, burning or smoldering wood, connector pipes, and glass doors.
- Watch for sharp edges and screw points
- Use proper lifting techniques: stand close to the object, bend knees, keep back straight, let legs and buttock muscles do the lifting.
- Stop working outside when conditions become unsafe, including darkness or icy conditions.

7.2. Power Tool Equipment

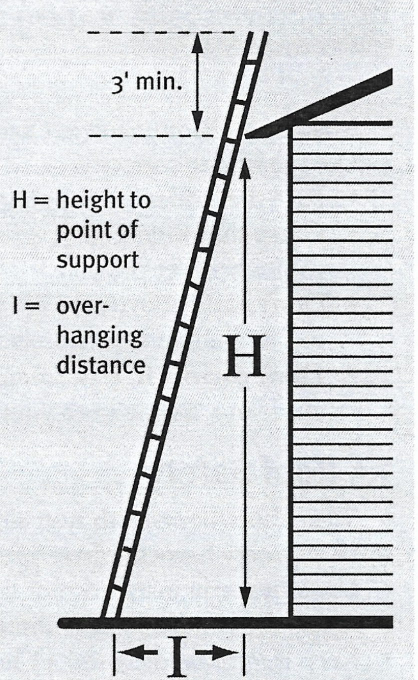
- Make sure all tools are in good working order and blades, drill bits, etc. are sharp and in good condition
- Make sure all tool guards are in place and working
- Make sure all tools and extension cords are properly grounded. Ground Fault Circuit Interrupter (GFCI) outlets or cords are recommended for outdoor use
- Use power tools only for the work they are intended

7.3. Weather Safety

Do not start or continue work outside when conditions become unsafe, including due to the following weather conditions:

- **High Wind**
    - Do not climb ladders or work on roofs during high wind.
- **Ice**
    - Drive with extreme caution.
    - Do not work on icy roofs.
- **Lightning**
    - When thunderstorms are in the area but not overhead, lightning threat can exist even when it is sunny, not raining, and skies are clear in the immediate area.
    - You should consider yourself at risk when lightning can be seen or heard.
    - A minimum guideline is to immediately seek or be in a safe location when the delay between the lightning flash and its sound is less than 30 seconds.

How it works: ladder placement



The OSHA recommendation for ladder placement is basically for a right triangle formed with the hypotenuse the ladder (from the ground to the roof support point) and the vertical distance from the roof support point to a point on the ground directly below it one side and the distance from the point on the ground to the base of the ladder the other side. The 1 to 4 ratio assures this.

To calculate the position of the base of the ladder:
- Measure the vertical distance from the point of support on the edge of the roof to the ground below, for example 18 feet.
- Divide this distance by 4. This is the horizontal distance from the point on the ground below the roof support point out to the base of the ladder. In the example, the distance would be 18 divided by 4 = 4.5 feet.

An alternative method of estimating ladder placement is a hands-on method:
- The technician stands erect with toes against the feet.
- The arms are extended out at a 90O angle.
- The ladder is positioned at the proper angle when the hands reach, but do not go beyond, the ladder side rails in this position.

A third method may be provided by the ladder manufacturer's instructions and set up label on the ladder. The ladder is set so that the line on the label is level.

- Large permanent buildings and fully enclosed metal vehicles are considered safe locations. With regard to vehicles, the protection comes from the metal cage conducting most of the electricity of a strike to the ground, not from any insulation provided from the rubber tires. Reported injuries to people in cars struck by lightning make it clear that occupants must not be touching metal objects that connect to the outside of the car, such as door and window handles, radio dials, gearshifts, etc. The National Lightning Safety Institute recommends pulling to the side of the road in a safe manner, turning on emergency blinkers, keeping windows rolled up, turning off the engine, putting hands in one's lap, and waiting out the storm.
- Unsafe outdoor locations include being near metal or water, under trees, on hills.
- Indoor locations that should be avoided include near windows and doors, near appliances and electronic equipment, and near fireplaces.
- A minimum guideline for resuming outside work is 30 minutes after the last observed lightning or thunder, but careful observation of weather conditions should continue.

7.4 Ladder Safety

- Fasten ladders carefully and securely to the vehicle. Check security of ladders on vehicle often.
- Use a ladder with the proper rating for the job. Refer to the usage label on the ladder.
- Find the best access location:
  - Stay away from electrical service entrances and power lines. Be cautious with aluminum ladders around power lines; electrocution can occur even where there is no direct contact with power lines.
  - Find even surface for the ladder legs or use ladder levelers.
  - Find similar surfaces for both legs
  - Stake or tie-down the lower end of the ladder to prevent outward slipping, or have someone hold the ladder in place.
  - Tie off the ladder at the roof, particularly when working in windy conditions where the ladder can blow over and injure someone or damage property
  - Avoid placing ladders in areas such as passageways, doorways, or driveways where they can be displaced by workplace activities or traffic, or secure the ladder to avoid accidental movement or use a barricade to keep people and traffic away.
- Place the ladder correctly against the house:
  - OSHA calls for the side rails to extend at least 3 feet above the upper landing surface (roof).
  - OSHA also calls for ladders to be placed at an angle so that the distance from the foot of the ladder measured horizontally to the point on the ground directly below the support point for the ladder on the roof is one fourth the vertical distance from the roof support point to the point on the ground directly below the roof support point (see illustration).
  - Place the ladder so that both rails are fully supported and there is extra room on each side in case the ladder shifts.

- Make sure the homeowner keeps children and pets away from ladder/working areas.
- Use the ladder correctly:
    - Face the ladder while going up or down the ladder
    - Grasp the ladder rails, preferably with two hands. Use a rope and bucket to move materials and tools to and from the roof whenever possible.
    - Don't stand above the highest safe standing level, typically identified on a step ladder label as the second rung from the top and on an extension ladder label as the fourth rung from the top.
    - Don't overreach, lean to one side, or stand on one foot, which can cause loss of balance or tipping of the ladder. As a guideline, always keep your belt buckle within the rails of the ladder. Reposition the ladder close to the work.

7.5 Roof Safety

- Wear shoes/boots with non-slip soft soles, such as soft crepe or gum
- Use a safety harness where appropriate
- Use a properly installed roof ladder with a steel ridge hook where appropriate
- Assess the condition of chimneys to decide whether a ladder can be leaned against the chimney
- Keep electrical cords and air hoses from under feet
- Prevent parts, tools, construction material, etc. from rolling or blowing off the roof
- Never throw anything off the roof

7.6 Hazardous Materials Safety

- Guidelines for preventing harm from hazardous materials encountered on the job include:
- Use mask/respirator when cutting potentially hazardous materials such as ceramic fiber or when handling fiberglass insulation.
    - Use type of filter appropriate for material's potential contaminant/hazard.
    - Store mask/respirator in airtight container when not in use to avoid dislodging and spreading contaminants.
- Avoid skin contact with creosote, which is carcinogenic.
- Follow all requirements and precautions for renovation work that requires EPA Renovation, Repair, and Painting Program (RRP) Certification or state/local requirements for containment of lead. Conditions that may necessitate RRP Certification include:
    - Homes built before 1978
    - Repair and maintenance activities for hire that disturb 6 square feet or more in the interior of the home or 20 square feet or more on the exterior
    - Regardless of whether or not children or pregnant women reside in the home and whether or not the residing owner acknowledges that the rule work practices are required (no "opt-out provision").
- Avoid disturbance of asbestos, asbestos piping materials, and materials known or suspected of containing asbestos.

7.7 Gas Safety

- If there is an odor of gas, test for leaks. Until the source has been found and corrected, and adequate time passed for dissipation, do not use flame or allow the appliance to come on.
- Shut gas off at shutoff valve when appropriate.
- Disconnect remote control/thermostat when gas must be available to appliance, but appliance should not come on.
- Follow the proper procedure for lighting the appliance and know the ignition sequence for the specific appliance.
- After servicing a direct vent appliance, open (remove glass) before lighting.
- Leak test all fittings disturbed during service.
- Know emergency procedures for significant gas leak.
- It is recommended to document (and have homeowners sign) every installation that requires disturbing/penetrating the structure as a record that proper procedures have been followed in all installations, whether they require certification or not.

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[1] Check with EPA at http://www.epa.gov/lead for current information regarding certification requirements.

[2] States and localities may have different regulations than EPA for renovations in target housing. Check with your state and local housing and environmental agencies to obtain information about such requirements.

Chapter 8 Installation Guidelines

Proper planning and installation of gas venting systems is an important safety and appliance performance concern. Before beginning installation and even installation planning, there are a number of important areas that require attention and decisions.

8.1 General Venting Installation Concerns

8.1.1 Appliance/Venting Compatibility

Many hearth appliances are tested and listed for use with a specific type or types of venting system. Safety testing has only been performed with the venting type(s) listed and referred to in the appliance manufacturer's instructions. In some cases, only venting systems produced by specific venting manufacturers are acceptable. There can be significant safety and liability consequences from using any venting system other than those specifically approved by the appliance manufacturer for each specific appliance.

8.1.2 Manufacturers' Instructions

The tendency to overlook appliance and venting manufacturers' instructions must be strictly avoided. Not only do instructions vary slightly from manufacturer to manufacturer, but any manufacturer may change instructions with revisions of standards governing instructions and/or with model changes. The investment of a few minutes to review instructions and to check for changes can prevent consequences ranging from nuisance to harm and damage. Failure to follow manufacturer's venting instructions can result in poor appliance performance, voiding of the manufacturer's warranty, and the assumption of considerable liability, possibly for the loss of property and life.

8.1.3 Regulations and Authority Having Jurisdiction

Applicable codes can also change, so it is worthwhile to periodically review them. Moreover, the authority having jurisdiction, the person or agency who issues permits, inspects installation, and/or issues approvals, has final say regarding the acceptability of appliances, venting materials and systems, and installation methods.

8.2. Venting Components

Only listed or manufacturer specified components should be used. Field construction of some components may be allowed, following manufacturer's instructions. Type B vent manufacturers may list other manufacturers' systems to which their systems can be connected using listed adapters.

Firestop Spacer. Firestop spacers block the pipe penetration opening and prevent unwanted communication and air flow between building levels. Firestops also provide lateral pipe support. They are required at every floor/ceiling through which the pipe passes. Firestop spacers must be installed according to manufacturer's instructions, which may include a different position for the firestop for a floor/ceiling penetration (above or below the framed opening) depending on whether a finished room or unoccupied attic is above.

Pipe Sections. Manufacturer's instructions specify limitations of adjustable length sections use and methods of securing the sections.

Elbows. Elbows allow for a change of direction in the vent, often to bypass obstructions. Elbows are available as 15°, 30° 45°, and 90° offsets depending on the type of pipe and installation situation. 45° and 90° offsets are not available for solid fuel chimney systems (45° are acceptable in Canada). Some manufacturers offer adjustable elbows that provide different offset angles. Some appliance manufacturers specify whether a 90° elbow can be used off the top of the appliance or whether a vertical section must be below the first elbow. Proper support of offsets (elbows and pipe sections between) is an important safety consideration. Strap components or approved strapping material should be installed to provide support. Attention should be paid to minimum clearances to combustibles parallel to the inclined pipe section and to offset penetrations of floors/ceilings/walls.

Wall thimbles. A wall thimble is required for installations that penetrate a wall. It is required to extend from one side of the wall to the other. Wall plates cover the framed opening. The air space between the thimble and the pipe must be maintained.

Tee and cap. A tee turns the direction of the pipe and, in combination with a wall support bracket, positions and supports the vertical pipe above it. The cap on the bottom allows access for cleaning. The cap must be in place and secure for operation.

Roof flashing. A flashing seals the opening as the vent pipe passes through the roof (with a storm collar) and helps secure the vent laterally. Flashings are often available to accommodate various roof pitches. The top edge of the flashing is secured under the roofing material.

Storm collar. This metal band is secured and sealed (with approved sealant) around the pipe above the roof flashing to divert water off the pipe and onto the flashing.

Termination cap. The termination cap should be a listed component for the venting system.

8.3 Natural Draft Installation Considerations

8.3.1 Adequate Ventilation

Since natural systems draw combustion air from inside the house, ventilation must be an installation concern. There are two situations that call for review and/or action:

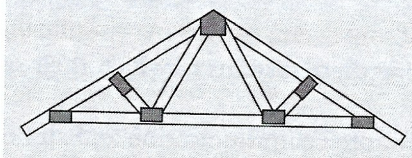
Inadequate volume for combustion air. It may be necessary to determine whether there the space in which the appliance is located has sufficient volume to supply the combustion air needs of fuel burning appliances in the space. The calculation and determination is done based on the type of construction and whether the space is confined or not or using the Standard or KAIR methods for gas installations.

Negative pressure conditions in the house. Strong negative pressure can prevent the appliance from performing properly and/or cause down draft resulting in spillage of combustion by-products in the home. Spillage may include a dangerous release of carbon monoxide. Causes of negative pressure can include:

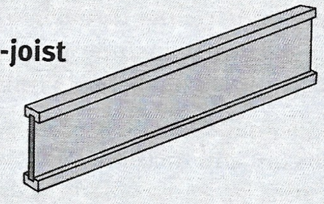
- Stack effect of the building
- Exhaust appliances (mechanical fans such as power exhausts for bathrooms and kitchen ranges, as well as other atmospherically vented appliances such as solid fuel fireplaces)
- High winds
- Inadequate make-up air in tight construction

Solutions to negative pressure problems include connection of approved outside air kits to the appliance, providing outside air to the room according to approved methods, or installing balanced make-up air systems.

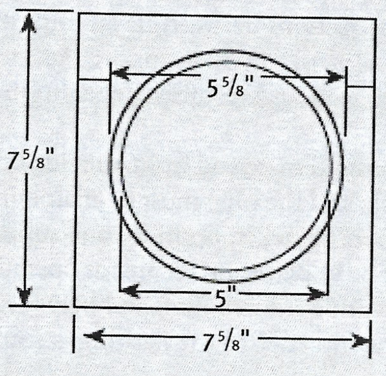
Engineered truss



I-joist



Venting cutout dimensions:
flat surface , $5\frac{5}{8}$" O.D.,
1" clearance required



8.3.2 Vent Size

The size (diameter) of the vent system for an appliance is usually specified by the appliance manufacturer. The cross-sectional area of the vent should not be smaller than the area of the appliance vent connector. Some exceptions may apply; refer to local codes.

8.3.3 Common Venting

Older homes may have more than one appliance vented in a single flue. Each modern solid-fuel and gas appliance requires its own flue. However, the fuel gas codes allow gas appliances located on different floors of a building to sharing a common vent (multistory venting) if they are installed in areas that are separate from the habitable space. By nature, gas hearth appliances are installed in living spaces, so they are prohibited from this type of multistory common venting. The issue of common venting of gas appliances in habitable spaces on the same floor is not specifically addressed in venting requirements in the fuel gas codes, and therefore not prohibited according to the codes. However, most manufacturer instructions and many local building officials require each gas hearth appliance to have a separate flue.

8.3.4 Vent Route and Configuration

There are a number of considerations regarding the location, route, and configuration of the vent system, including:

Construction Features. Exercise caution regarding wiring, ductwork, and other possible obstructions in planning and executing the vent route. Avoid features such as engineered trusses (prefabricated structural assemblies that hold up the roof and top floor ceilings) and I-joists (I-shaped prefabricated structural members) that must not be cut or altered.

Clearances to combustibles. Be sure to allow enough room for the outside measurement of the pipe plus at least the minimum air space clearance to combustibles in all directions. Air space clearances must remain free and cannot contain any material; combustible or non-combustible. Read and follow the installation manual carefully. When calculating clearances, be sure to use the outside diameter (o.d.) not its nominal size. For example (see diagram on previous page), 5 inch Type B vent pipe refers to the inside diameter (i.d.); the outside diameter may be 5⅝ inches or larger. Calculating the minimum size of a cutout on a vertical wall or horizontal (flat) ceiling is simply a matter of adding the outside diameter of the pipe to twice the clearance (adding the clearance on opposite sides of the pipe). For example, 5 inch pipe (nominal size) with a 5⅝" outside diameter and 1 inch clearance calls for a minimum opening size of: 5⅝" (pipe diameter) + 2 x 1" (clearance on opposite sides of the pipe) = 7⅝" diameter circle or a 7⅝" x 7⅝" square opening. Determining cutout size on a pitched roof can be more complicated. As pitch increases, the length of the cutout on the slope of the roof increases in order to maintain minimum clearances.

¼ inch rise per foot the easy way

Many bubble levels have two sets of marks. Positioning the bubble inside the inner marks indicates level. Positioning the edge of the bubble inside one of the outer marks indicates a 2% slope, approximately ¼" per foot rise.

Horizontal run and rise. Horizontal runs should be kept to a minimum and avoided whenever possible. When horizontal runs are necessary, they should be inclined away from the appliance to rise at least ¼ inch in every foot of lateral run (for example, a 2 foot horizontal run should rise at least ½ inch, see text box below for an method without calculation). Appliance manufacturers may specify a maximum horizontal run or specify minimum vertical height for different horizontal runs. They may also specify a maximum rise to run ratio. The fuel gas codes limit the maximum horizontal length of connectors in relationship to the total height of the vent:

- For single wall connectors, maximum horizontal length no more than 75% of the total vent height
- For Type B vent double wall connectors, maximum length no more than 100% of the total vent height.
- Some direct vent gas appliance manufacturers require ¼" per foot rise. Others do not. Be sure to check the specifications for the specific appliance you are installing.

Appliance manufacturers, however, may require that the horizontal run be no more than 50% of the vertical height. Read and *follow the installation manual carefully.*

Number and angle of turns. Appliance manufacturers may specify the maximum number of turns (offset elbows and tees) and also any adjustments in the height of the system based on the number of turns. In general, it is usually best to avoid turns in venting systems whenever possible or to use 45° elbows instead of 90° elbows.

Minimum vent height. Appliance manufacturers may specify minimum vent height.

Exposure to cold. A venting system that is exposed to cold temperatures may cause enough heat loss that could allow unwanted condensation and reduced draft.

8.3.5 Assembly

Vent pipe may be a snap lock design that requires pushing the sections of pipe and connecting components together. If the vent manufacturer calls for or allows the use of sheet metal screws (for the termination cap, for example), do not penetrate the inner pipe wall with them. Assemble the sections of pipe in the direction of the arrows on the pipe.

8.3.6 Vent Termination

The height of the termination above the roof is the primary consideration. Vent height is measured from the highest point of roof penetration to the lowest discharge opening of the vent (where the cap joins the vent). Vent and/or appliance manufacturers may provide a diagram and table of minimum height above the roof according to ranges of roof pitches. The minimum height requirement will vary for woodburning, pellet and gas installations. Woodburning factory-built fireplace manufacturers specify minimum and maximum chimney height. Woodstove manufacturers may have similar requirements. Both types of appliances and most codes require the 10 foot/2 foot/3 foot rule for minimum chimney height above the roof:

- The height of the chimney must meet or exceed both of the minimum requirements.
- These minimum heights may have to be exceeded, however, for adequate draft and satisfactory appliance performance. Additional height can help improve draft and may make the difference in marginal situations. It will not, however, cure severe draft problems.

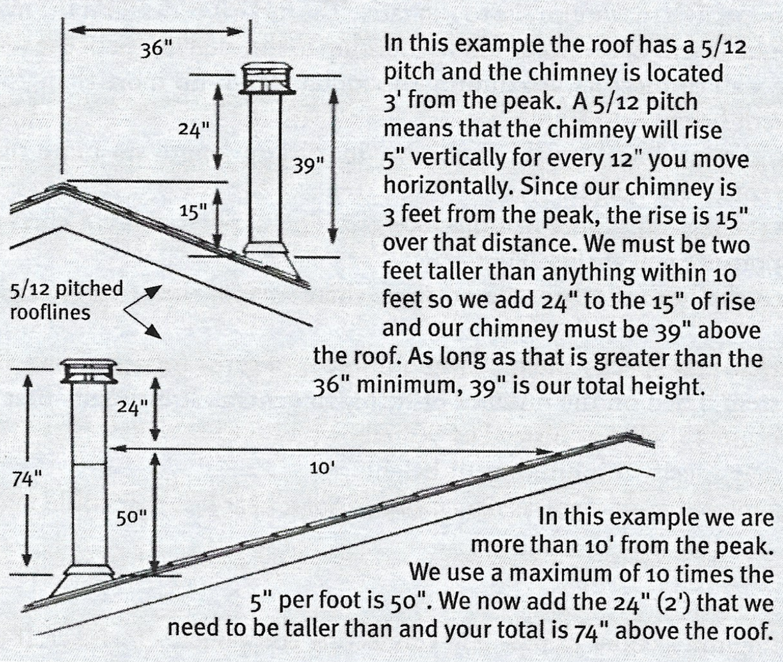
The fuel gas codes offer tables based on roof pitch for gas vent minimum height above a roof penetration if the vent penetrates the roof for a non-powered (natural draft) exhaust. The tables can be used for systems with a listed cap or roof assembly for vents (12 inches or smaller) that are at least 8 feet from a vertical wall or similar obstruction. If the vent is closer than 8 feet, it must terminate at least 2 feet higher than any portion of a building within 10 feet of the vent for fuel gas codes. In addition, B vent must terminate not less than 3 feet above any forced air inlet located within 10 feet. Minimum vent height may have to be exceeded for proper venting performance if there are excessive restrictions to flow such as horizontal vent runs and/or elbows or tees. In some cases, direct vent may be allowed to vent totally horizontally.

IRC and NFPA 211 recognize pellet manufacturers' instructions, which may require 2' of pipe above the highest point of vent penetration. For instructions referencing NFPA 211 or not providing instructions, the code requires a minimum of 1' of pipe above the highest point of roof penetration for vent with mechanical vent exhausters. However, to some AHJs, a pellet stove is considered a solid-fuel appliance and they may require the same 3', 2', 10' height as woodburning appliances have.

Appliances installed in higher altitudes may need stronger draft to deliver a greater volume of air at higher altitudes to make up for the lower concentration of oxygen. Recommended sea level chimney height may need to be increased by 2-4% per 1,000 feet of elevation. Check with the appliance manufacturer.

Vent caps must be listed components, and they must be installed in a vertical position.

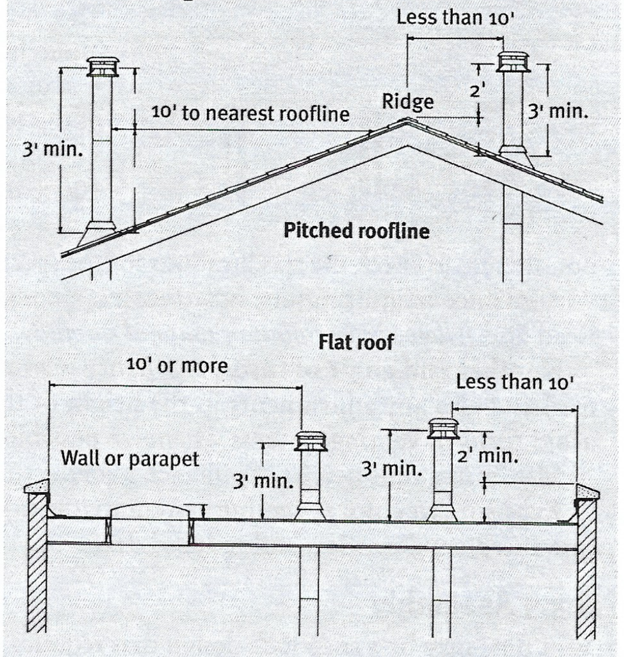
Determining vent system height on a pitched roof



In this example the roof has a 5/12 pitch and the chimney is located 3' from the peak. A 5/12 pitch means that the chimney will rise 5" vertically for every 12" you move horizontally. Since our chimney is 3 feet from the peak, the rise is 15" over that distance. We must be two feet taller than anything within 10 feet so we add 24" to the 15" of rise and our chimney must be 39" above the roof. As long as that is greater than the 36" minimum, 39" is our total height.

In this example we are more than 10' from the peak. We use a maximum of 10 times the 5" per foot is 50". We now add the 24" (2') that we need to be taller than and your total is 74" above the roof.

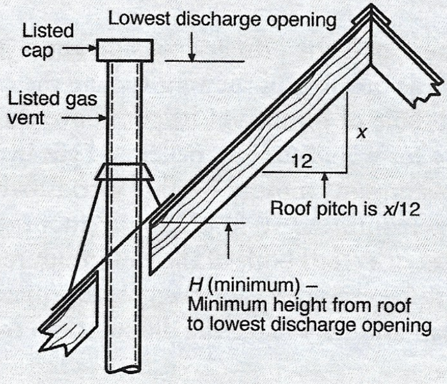
Woodburning



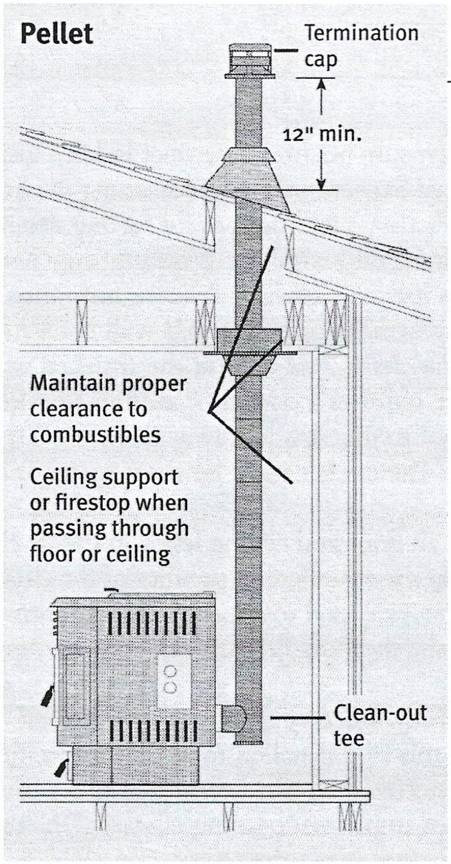
8.3.7 Roof Pitch

Roof pitch reflects the amount of vertical distance that the roof rises over a given vertical distance, or run. In standard pitch notations, the run is assumed to be 12 inches, and the rise is the amount of vertical rise over each 12 horizontal inches. For example, a roof that rises 6 vertical inches over each 12 inches of horizontal span has a pitch of 6/12. Other less common ways of noting pitch include "6:12," "6 in 12" and "6 over 12."

Gas



Roof pitch	H (minimum) ft.	m
Flat to 6/12	1.0	0.30
6/12 to 7/12	1.25	0.38
Over 7/12 to 8/12	1.5	0.46
Over 8/12 to 9/12	2.0	0.61
Over 9/12 to 10/12	2.5	0.76
Over 10/12 to 11/12	3.25	0.99
Over 11/12 to 12/12	4.0	1.22
Over 12/12 to 14/12	5.0	1.52
Over 14/12 to 16/12	6.0	1.83
Over 16/12 to 18/12	7.0	2.13
Over 18/12 to 20/12	7.5	2.27
Over 20/12 to 21/12	8.0	2.44


Pellet
Termination cap
12" min.
Maintain proper clearance to combustibles
Ceiling support or firestop when passing through floor or ceiling
Clean-out tee

8.3.8 Cathedral Ceilings

Because of the slope of the cathedral ceiling, care should be taken to extend the chimney sufficiently far into the room so that the chimney connector will meet the minimum clearance requirement from the sloped combustible ceiling. The greater the slope of the ceiling, the farther into the room the chimney section must extend.

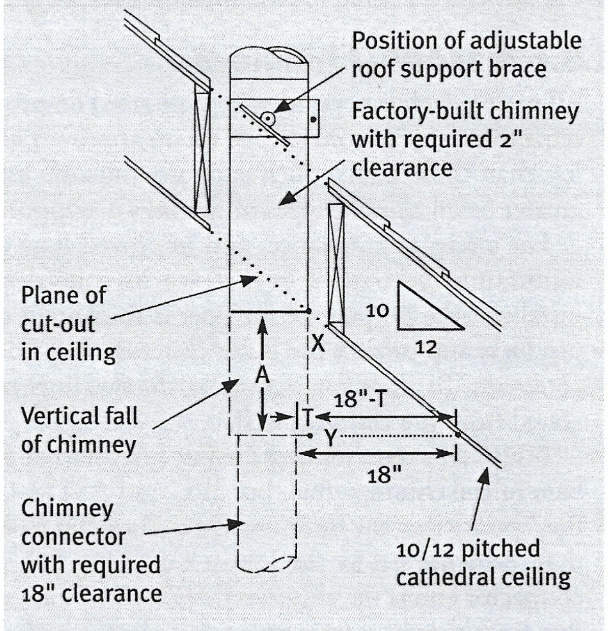
The roof cutaway illustration provides an example. It shows a 6" diameter chimney connector, joined to a 9" outside diameter factory-built chimney that penetrates a 10:12 pitch ceiling at least 3 feet from any wall. Our task is to calculate the length of chimney needed below the ceiling penetration so that the chimney connector is 18 inches from the sloped combustible ceiling.

The most practical measuring points are along the lower side of the chimney, points X and Y, so we first determine the distance from the lowest point of the chimney (X) to the ceiling. Since the chimney is 3" larger in diameter than the connector, the distance between the outer wall of the connector and outer wall of the chimney (in illustration see T, which is ½ the difference in the diameters of the chimney and connector) is 1 ½". Point X is therefore 1½" closer to the ceiling than the connector. We subtract this difference from the required minimum clearance for the connector: 18 – 1.5 = 16.5". This is the distance between the chimney and the ceiling at which the connector will be 18" from the ceiling.

We can then calculate:

- Multiply the horizontal run (in inches) times the ceiling pitch to get the fall:
  - 10/12 x 16.5 = 165/12 = 13.75" (round up to 14").
- The chimney must be extended 14 inches below the ceiling penetration, *measured from the low point on the ceiling where the chimney passes through the ceiling*, in order that the connector joining it will be at least 18 inches horizontally from the nearest point on the ceiling.

Calculating minimum length of interior chimney for cathedral ceiling
(example with 10/12 pitch ceiling)


Position of adjustable roof support brace
Factory-built chimney with required 2" clearance
Plane of cut-out in ceiling
10
12
X
A
18"-T
T
Y
18"
Vertical fall of chimney
Chimney connector with required 18" clearance
10/12 pitched cathedral ceiling

8.4 Mechanical Venting

Requirements for mechanical venting systems include:

- Listing and instructions of appliance and mechanical draft system
- Gas appliances require a full interlocking with appliance control valve so that gas flow to main burners is cut off if there is inadequate draft
- Termination requirements for mechanical draft systems
- No less than 7 feet above grade where adjacent to public walkways
- At least 3 feet above any forced-air inlet within 10 feet
- At least 4 feet below, 4 feet horizontally, and 1 foot above any door, operable window or gravity air inlet into building
- At least 12 inches above grade.

8.5 Chase Considerations

A chase is a vertical enclosure, usually constructed of wood, which houses and conceals a chimney. The best appliance location for venting performance is on an interior wall, which provides the maximum amount of the vent inside the building envelope. Often, however, an exterior wall is the specified location, and often a chase is built to house both the fireplace and vent, or just the vent.

Chase Insulation. Consideration should be given to properly weatherize the chase to prevent unnecessary heat loss or cold air infiltration through the chase and fireplace system. Although not required by all code bodies, in cold climates, this may require insulating the chase enclosure. Insulation, preferably unfaced batts, should be installed on the exterior walls of the chase, and appropriately sheathed with sheetrock, which is also known as drywall or gypsum board. Remember to keep insulation away from all spaces where air space clearance is required. Additionally, a thermal barrier may be placed under the firebox, if the entire system is installed in a cantilevered chase. Check the fireplace manufacturer's instructions for further details.

Sealing the Chase. In some instances, especially in cold climates, chases constructed inside the dwelling may need special considerations. In extremely tight structures, where air exchange rates are low and interior relative humidity is high, it may be beneficial to insulate, seal and vapor barrier the chase similar to treatment given outside wall construction in such dwellings. The vapor barrier should be placed on the room side of the chase, just behind the finished wall sheathing, unless local code authority indicates otherwise. The exterior of the chase requires a cricket or saddle, a peaked secondary roof section constructed on top of, and perpendicular to the primary roof to divert water away from the chase if it is more than 30 inches wide, measured perpendicular to the slope of the roof. The cricket must be sheet metal or of the same material as the roof.

Firestopping the Chase. Firestop spacers should be installed to correspond with all floor and ceiling levels in the dwelling, both for fire safety and for heat loss prevention. Firestop spacers in the chase help the main lateral stability of the chimney to ensure that it stays in place. They slow the spread rate of an unfriendly fire from one level to another. They minimize heat loss from the fireplace system. If the chase is to cut through the eave portion of the dwelling, it must not communicate with open attic spaces. Local codes vary on details of chase construction.

Chase Vent Termination. The method of termination must be approached carefully, since safety issues are involved. If a vent termination is to be installed directly on a field-constructed chase, the vent must be installed to within a specified clearance to the top of the chase. The chase top must be made of noncombustible materials if within a certain distance from the termination. The chase cover should be weather resistant sheet metal and designed to prevent pooling of water. The termination cap must be the listed cap for the venting system. The appliance manufacturer may require noncombustible spacers between the chase top and combustibles. Decorative shrouds, metal vent termination coverings with openings that help conceal the termination cap and are used for aesthetic purposes, must not be installed at the termination of gas vents unless the shrouds are listed for use with the specific gas venting system and are installed according to manufacturer's instructions.

8.6 Masonry Chimneys

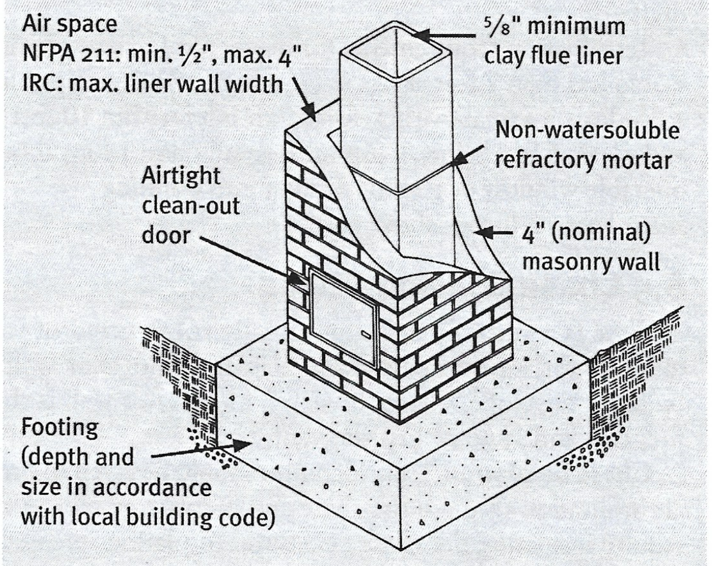
All masonry chimneys must be supported on properly designed footings of reinforced Portland cement concrete, reinforced refractory cement concrete, or on an approved load bearing, noncombustible material having a fire resistance rating of not less than three hours. Such supports must be independent of building construction. Most local building codes specify in greater detail allowed types of footings or supports. This is especially true in areas susceptible to seismic activity.

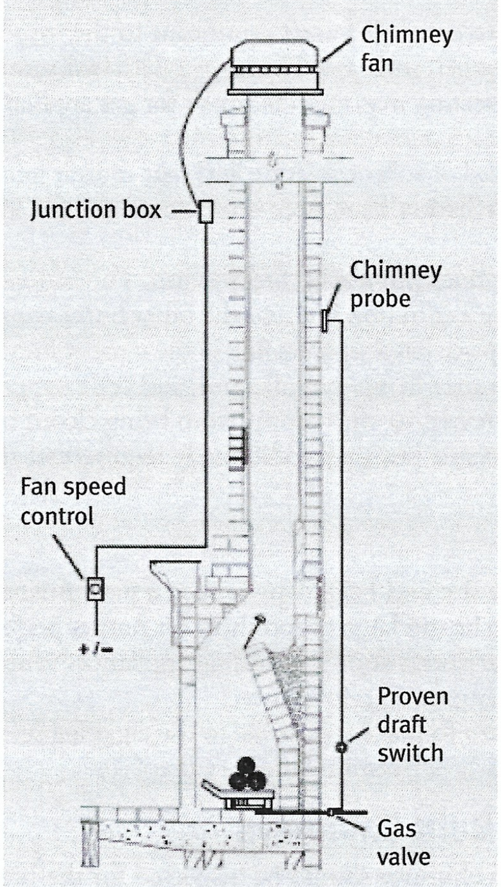
For safety, maintenance, and improved flow characteristics, masonry chimneys must be lined. A clay flue liner with a minimum thickness of ⅝ inch (or its equivalent) must be installed. The purpose of the liner is to contain combustion products and protect the outer chimney wall from heat and corrosion. To allow for expansion, the flue liner must be separated from the chimney wall.

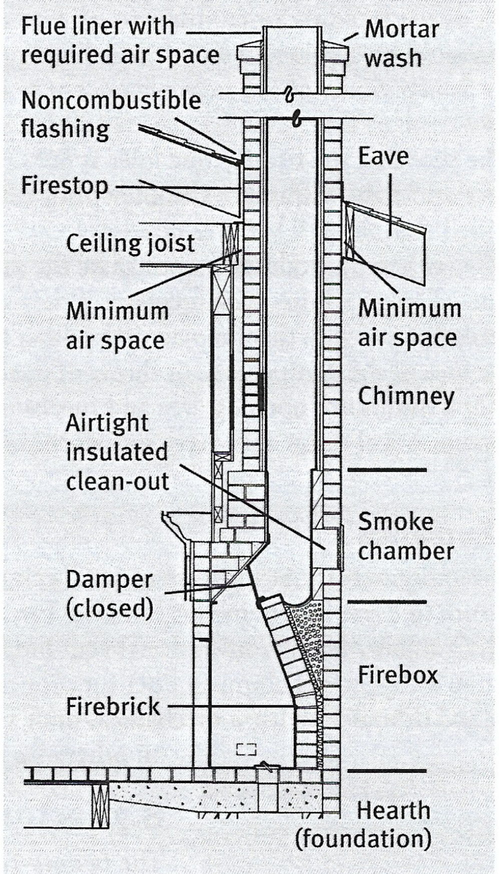
NFPA 211 requires that the flue liner start at or below the base of the chimney flue, but IRC and ASTM C 1283 further specify that the flue liner should begin at a point not less than 8 inches below the lowest breaching (where chimney connector enters the chimney). NFPA 211 indicates that the flue liner should terminate no less than 2 inches above the splay or wash at the top of the chimney.

The flue liner sections should be carefully bedded, one on the other, in a medium duty, non-water soluble calcium aluminate refractory cement mixture. Common mortar will not withstand the high heat and acid conditions associated with burning solid fuels, and is not approved by most codes. The integrity and durability of these joints is extremely important for both safety and structural reasons.

Masonry chimney construction




Masonry chimney: mechanical draft system


Masonry chimney construction details

The joints between the flue liner sections should be close-fitting and smooth, especially on the inside surface. This is accomplished by positioning and mortaring each clay flue liner section before the surrounding masonry is laid so that the joints are struck smooth inside (mortar protruding into the flue area is troweled smooth with the flue walls and removed) and do not leak. It is a significant hindrance to proper chimney operation and cleaning if flue tile liner joints are not smooth on the inside surface. It is common practice in the United States to use square or rectangular flue liners.

8.6.1 Masonry Chimney Condition

Since each masonry chimney is custom built and may have an unknown history of use, assessing its suitability and condition can be an important part of planning and installation of the hearth appliance. Inspection of the chimney may be a routine process for properly built and maintained chimneys, or it may be difficult and complex procedure involving judgment about concealed areas. NFPA 211, Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances, outlines a systematic approach to inspections to be undertaken by qualified technicians.

NFPA 211 Inspection: Level I. The first level of the NFPA 211 approach to inspection is limited in scope to readily accessible areas of the chimney, structure, and flue (exposed for inspection without the need for tools). Level I inspection, for our purposes here, is called for when an appliance connected to the chimney is replaced with one of similar type, input rating, and efficiency (for example, a gas log set is replaced for cosmetic or mechanical reasons with one with similar input rating). The scope of the inspection is for obstructions or combustible deposits (creosote) in the flue.

NFPA 211 Inspection: Level II. An NFPA 211 Level II inspection is called for, among other reasons not related to our purposes, upon addition of an appliance or replacement of an appliance with one dissimilar in type or input to the original one (for example, a gas log set installed in a fireplace that had been burning wood or a gas log set with significantly lower input). Another situation calling for Level II inspection is prior to relining the chimney (for example, with the addition of a gas fireplace insert). Level II inspections include all accessible interior and exterior portions of the chimney, including attics, crawl spaces, and basements. Accessible is defined as being exposed for inspection without damage to the chimney or building, but which may involve removing doors, panels, or coverings with commonly available tools. The scope of the inspection adds proper construction and condition of accessible portions of the chimney, proper clearances to combustibles in accessible areas, and the size and suitability of the chimney flues for connected appliances.

Level II inspections may therefore call for knowledge of masonry chimney construction details in standards such as NFPA 211 and/or local codes. Level II inspections may necessitate the use of specialized equipment, such as customized video equipment. If there are concerns or doubts about the condition of the chimney or the ability to inspect properly, contact a qualified chimney specialist, such as a Chimney Safety Institute of America (CSIA) Certified Chimney Sweep.

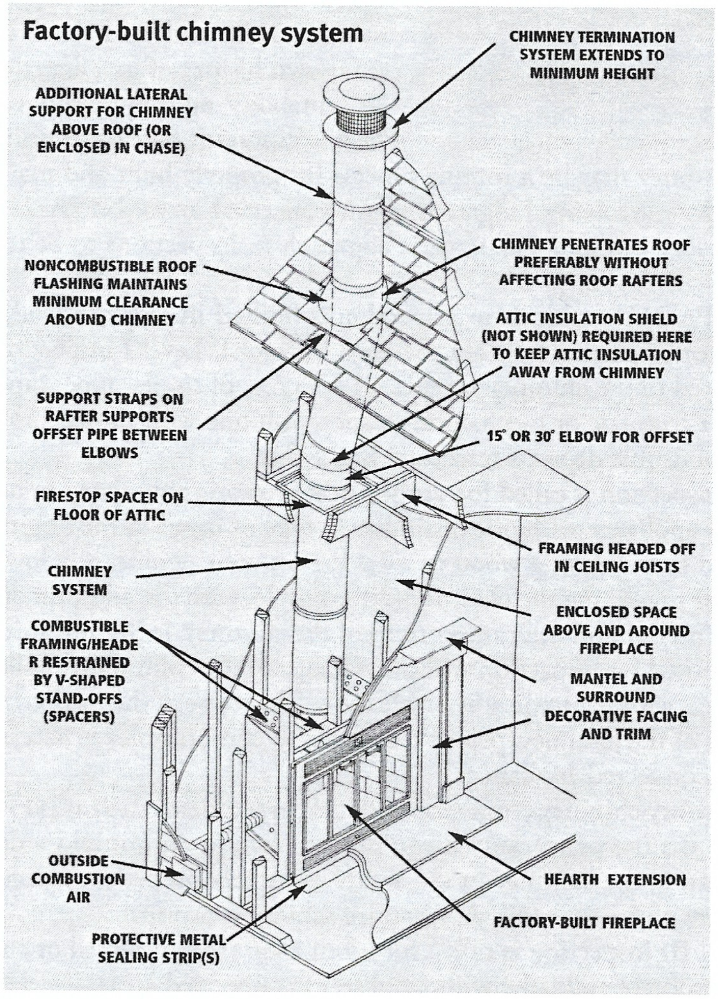
NFPA 211 Inspection: Level Three. An NFPA 211 Level III inspection is called for when a hazard is detected or suspected as a result of Level I or II inspections and cannot be properly evaluated without access to concealed areas. Level III may call for removal of components of the building or chimney to gain access to concealed areas significant to the inspection. Level III inspections certainly should be conducted only by qualified personnel, such as a Chimney Safety Institute of America (CSIA) Certified Chimney Sweep. Some of the areas of concern in inspecting masonry chimneys for gas appliance use include:

- **Condition of the flue liner.** Make sure that the fireclay flue liner is not cracked or soft or missing and that mortar joints between the liner sections are in place and tight. Clean the chimney prior to installation if creosote is present in the firebox, throat, or chimney flue. Use a qualified technician whenever necessary.
- **Connection of other appliances.** Gas hearth products cannot share the same flue with a solid fuel product. For example, a gas log set cannot be vented into one of two back-to- back fireplaces if they share a common flue and the other burns wood. On the other hand, the gas log set could be vented in that fireplace if the other fireplace has a separate flue in the same chimney.
- **Damper area.** Make sure that the area of the damper area or throat of the chimney meets manufacturer and code requirements. The manufacturer may call for a minimum opening area and means of preventing the damper from being closed beyond that size, such as a damper clamp. Local codes may have similar requirements, but may additionally require that the damper be removed or welded open.

8.6.2 Masonry Chimney Performance

Natural draft appliances have draft requirements that must be met. Check flue size and height for expected performance. Some manufacturers provide minimum flue size requirements, but flues can also be too large or too short for proper performance. An oversized flue may require a smaller liner. Conventional vent fireplace inserts and freestanding appliances vented into masonry chimneys usually require an approved chimney liner for proper sizing and performance.

In some cases, it may be possible and desirable to use a mechanical draft system to make it possible to use a gas log set in an otherwise poorly performing masonry fireplace.


Factory-built chimney system
CHIMNEY TERMINATION SYSTEM EXTENDS TO MINIMUM HEIGHT
ADDITIONAL LATERAL SUPPORT FOR CHIMNEY ABOVE ROOF (OR ENCLOSED IN CHASE)
CHIMNEY PENETRATES ROOF PREFERABLY WITHOUT AFFECTING ROOF RAFTERS
NONCOMBUSTIBLE ROOF FLASHING MAINTAINS MINIMUM CLEARANCE AROUND CHIMNEY
ATTIC INSULATION SHIELD (NOT SHOWN) REQUIRED HERE TO KEEP ATTIC INSULATION AWAY FROM CHIMNEY
SUPPORT STRAPS ON RAFTER SUPPORTS OFFSET PIPE BETWEEN ELBOWS
15° OR 30° ELBOW FOR OFFSET
FIRESTOP SPACER ON FLOOR OF ATTIC
FRAMING HEADED OFF IN CEILING JOISTS
CHIMNEY SYSTEM
ENCLOSED SPACE ABOVE AND AROUND FIREPLACE
COMBUSTIBLE FRAMING/HEADER RESTRAINED BY V-SHAPED STAND-OFFS (SPACERS)
MANTEL AND SURROUND DECORATIVE FACING AND TRIM
OUTSIDE COMBUSTION AIR
HEARTH EXTENSION
PROTECTIVE METAL SEALING STRIP(S)
FACTORY-BUILT FIREPLACE

8.7 Factory-Built Chimneys

The factory-built chimney should be inspected for the presence of obstructions or creosote that must be removed before installation. In addition, the chimney should be inspected for general condition and for proper installation.

8.7.1 Factory-Built Chimney Performance

The chimney should be evaluated for performance on the basis of its height, flue size, and number of turns to ensure proper performance. If a lining system is called for, an approved adapter kit should be used to connect to the chimney. In some cases, it may be possible and desirable to use a mechanical draft system in an otherwise poorly performing masonry fireplace.

8.8 Chimney Liner Systems

Both masonry and factory-built chimneys may require relining. Acceptable liner systems include single wall, flexible. The appliance manufacturer specifies the proper type and size of liner. Follow manufacturer guidelines for proper height, also.

Please note: Ovalizing round pipe decreases the cross sectional area, on site ovalizing of appliance flue collar sized connector will cause draft restriction and should be avoided. A 6inch diameter connector is roughly equivalent to a 4½ x 10 inch oval opening, while an 8 inch diameter connector is approximately a 4½ x 13 inch oval opening. Manufactured properly sized ovalized stainless pipe and transitional round to oval adapters are available. Kits are produced to facilitate connection through the fireplace damper; some of these kits have been safety tested and listed.

8.8.1 Liner Assembly

Rigid liner should be installed with the small end of the pipe down to keep condensation inside. Flexible liner should be handled and installed carefully to avoid puncturing the pipe. Flexible liner may have a flow direction that should be followed. There is less resistance for gases traveling in one direction through the liner than in the other direction. Check the label on the pipe and the manufacturer's instructions. An approved insulation sleeve for flexible liner may be advisable for installations in cold weather climates, particularly if large portions of the chimney are exposed to the weather.

8.8.2 Liner Termination

Factory-built chimney caps may be part of the cooling system for the chimney. Be sure not to block any of the air spaces that are part of the connection between the cap and the chimney.

8.9 Using Existing Chimneys

Consumers frequently wish to set hearth appliances on a fireplace hearth, insert them inside an existing fireplace or simply make use of existing chimney systems. From the standpoint of appliance performance and overall safety, existing fireplace chimneys may be significantly less than ideal for venting newer appliances. By design, a typical fireplace consists of a large opening and a chimney capable of handling large volumes of hot, high velocity gases in the range of 400 to 600 cubic feet per minute (cfm). The cross-sectional area of fireplace flues may range from 77 to 196 square inches.

The demands that most new appliances place on chimneys are different in quality and quantity from those of conventional fireplaces. In comparison to fireplace exhaust, the exhaust from newer solid fuel appliances that have a 6 inch flue collar require 28 square inches, gas appliances normally use a 4" (12 square inches) or a 5" (19.6 square inches) and pellet appliances normally use a 3" (7.07 square inches) or a 4" (12 square inches). Therefore relining the venting system may be required before a new appliance can use the fireplace chimney. NFPA 211 and IRC allow the cross-sectional area of the chimney flue to be as large as 2 or 3 times the cross-sectional area of the flue collar of the solid fuel appliance. Be sure to check the manufacturer's instructions for gas and pellet venting system requirements. Please also remember, while using an oversized flue may meet the code requirements, the appliance may not perform properly. Whether the new appliance relies on natural or mechanical draft, the proper size venting system is imperative as well as proper draft. Relining a chimney to the top will always be a more expensive option, but in the long run there is a distinct improvement in the performance as well as making it much easier to sweep and keep clean.

NFPA 211 requires a Level 2 Inspection when installing a new hearth appliance in existing masonry chimneys. For complete details about the NFPA levels of inspection, please see section 8.6.1 and section 8.8 for a discussion on the various liner systems.

Chapter 9 Communication with Owners

The sale and installation of hearth appliances often do not end with the first fire burned by the owner. It is important to be able to respond to users who may be unfamiliar with a new type of appliance. Knowing how to assist with operation and maintenance questions can help ensure maximum safety, satisfied customers, and referred sales.

9.1 System Operation

The role of education and communication cannot be overemphasized and should not be overlooked. While traditional fuel heating systems that utilize consistent fuels and automated controls require relatively little attention or understanding on the part of the user, fireplaces and stoves bring user responsibility along with economy, enjoyment, and self-reliance. The high degree of user involvement, including fuel selection and preparation, appliance operation, appliance and venting system maintenance (whether do-it-yourself or professional), and emergency procedures, necessitates a well-informed, perhaps skillful operator.

There are a number of sources of information: the appliance and venting manufacturer's instructions, internet sites, public service brochures and a few books. The best source for reliable and specific information, however, remains with those directly involved in selling and servicing the appliance and venting system. This direct involvement has the advantages of better communication, knowledge of specifics, and the possibility of hands-on demonstration. The opportunities for communication include the sales process, after installation instructions and demonstrations, "stove school" gatherings of users, direct mail, and follow-up phone calls.

9.1.1 Break-In Procedures

Once the appliance and all the component parts and accessories have been installed it is very important to follow the manufacturer's guidelines for proper break-in procedures. Cast iron, soapstone, firebrick and masonry all contain moisture. Slow, low heat fires are initially recommended to prevent cracks or damage while driving out that moisture. Appliance performance during the break-in time may not be as god as expected. High temperature paint used on hearth appliances must cure. Once the painted surface is heated, the curing process will result in some smoke in the home. Since different parts of the appliance heat up at different times, this process may take a few hours or multiple fires to complete the process. It is best to have an open window or door during this process.

9.2 System Maintenance

All users need to be aware of maintenance requirements. Chimney cleaning is included in the study manual for informational purposes and is not intended to serve as a guide to chimney cleaning. Certification of chimney sweeps is administered and granted by the Chimney Safety Institute of America (CSIA): 2155 Commercial Drive Plainfield, IN 46168 (317) 837-5362 or www.csia.org. The first recommendation is always service by a qualified professional. But all owners need to know inspection procedures and be able to recognize problems that require service.

9.2.1 Appliance Maintenance

The intense heat and adverse byproducts of combustion necessitate appliance maintenance. Common maintenance requirements are listed here; owner's manuals may identify other product specific maintenance needs and schedules. Routine maintenance like ash removal and glass cleaning can be easily undertaken by owners. Other maintenance tasks, particularly for woodstoves, usually call for professional assistance.

9.2.1.1 Ash Disposal

Ashes should be removed with a shovel and bucket. A household or shop vacuum should not be used to remove ashes, both because of the possibility of fire from an ember and because the fine ash will damage the vacuum motor. Most household or shop vacuums will not contain fine dust as is found in ashes. (Special ash removal vacuums are available.) The ashes that are removed from the fireplace should always be placed in a metal container with a tight fitting lid.

While the container is being filled, and after it has been filled, do not place the container on a combustible floor or rug. After the ashes have been removed from the fireplace, the covered metal container should be placed

9.2.1.2 Glass Doors

- Clean glass only when completely cool.
- Use nonabrasive cleaner.
- Clean metal finish only when completely cool.
- Use only nonabrasive approved cleaner on metal finish.
- Lubricate sliding mechanism on fireplace glass doors according to manufacturer's instructions.

Paint tips

- Clean surface
- Stove paint will not adhere properly to grease, oil, graphite, or other foreign material.
- Paint may come off in large patches.
- Check with the stove paint manufacturer for cleaning instructions.

Paint thickness

- Peeling and/or cracking (resembling shattered glass) of paint may occur if more than one coat of paint is applied to the original finish.
- Paint may come off in thin pieces.
- Check with the stove paint manufacturer for instructions for removal of the first coats.

Application technique

- The gas used to provide pressure to expel the paint is flammable. Avoid sparks or open flame and use only in well ventilated areas.
- Bring the can to room temperature by running it under hot water if necessary to avoid paint "spitting" in droplets from the can.
- Shake the can for a minute after the marble in the can begins to rattle to mix the paint thoroughly (light colors may require more shaking because they have thicker pigments).

Spray tip condition

- For first use of a can of paint, spray onto a newspaper to release any materials that may have separated and to clear out the delivery tube.
- Avoid extending your finger over the front of the nozzle, which can cause "spitting" of paint drops.
- Trigger mechanisms are available to prevent this problem and to make spraying more comfortable.
- If a can with paint remaining is not to be used for a period of time, turn the can upside down and spray until no longer comes out to clear the tube and nozzle.

Paint curing

- Curing involves burning off the "air dry" resin that gives the stoves their preburn appearance and applying the temperatures necessary to cure the silicone resin that gives the paint its high heat resistance. The silicon resin cures at approximately the same temperature that the air dry resin burns off (approximately 475°F).
- Customers should be warned to ventilate their house during the curing and that the process may take 3 hot firings or more to complete.

outside, away from building, vehicles and other combustible items. If the ashes are to be disposed of in the soil by burying, or by transfer to another container, keep them in the closed container until completely cooled. Embers may remain active in the insulation provided by the ashes for more than a day.

9.2.1.3 Gaskets

Fiberglass gaskets that seal appliance doors and glass deteriorate with time and heat. It is important that they seal out unwanted dilution air properly. Door gaskets can be checked for seal by closing the door on a dollar bill. If the dollar bill can be pulled out easily, it is not sealing properly (the bill should be moved to different locations and tested). Visual inspection while the appliance is being used (or with a flashlight in the closed, unused appliance) in a dark room also can reveal gaps. It may be possible to adjust door latches or hinges to tighten the gasket. If not, the gasket should be replaced with the proper sized replacement gasket. The condition of gaskets should also be inspected. If the gasket is brittle or crumbles, it should be replaced.

Finally, changes in glass cleanliness may indicate deterioration of glass gasket. To replace door gaskets, the old gasket and cement must be removed and the groove cleaned with a wire brush or other tool. There are numerous sizes of gasket available; the proper replacement size is essential. Fitting the gasket can be tedious. Basically the procedure starts with placing the gasket in the groove without cement and without stretching the gasket. If the door closes properly, this is the right length. If the door will not close or is difficult to close, the gasket is removed, a small portion cut off, the remainder stretched slightly when replaced, and tested again. When the proper length is attained, the gasket is removed and a bead of gasket cement is applied in the groove. Excessive cement should be avoided. The gasket is replaced and the door closed and opened to make sure the gasket cement does not contact the appliance. The door can then be closed; most gasket cement manufacturers call for overnight curing without appliance use.

Glass gasket is available with adhesive backing for easy installation for some appliances.

9.2.1.4 Appliance Seams

Cast iron appliances are assembled with tongue-in-groove plates sealed with furnace cement. Furnace cement deteriorates with time and heat. Eventually portions of the hardened cement will fall out, leaving an air gap between plates. These gaps affect: performance by introducing unwanted air, safety by being a source of combustion air in a chimney fire, and appliance durability by creating hot spots. These hot spots are usually the first indication of gaps in the seams; the paint turns white close to the gap in the seam. Light from a fire or flashlight in the firebox in a dark room can also reveal some gaps.

Applying furnace cement to the outside and inside of the affected area is ineffective because the cement will contract with heat and fall off. The appliance must be disassembled, grooves cleaned, new cement applied, and reassembled. Manufacturer's instructions are usually available; professional service is usually advisable.

9.2.1.5 Paint

High temperature paint gradually deteriorates. The hottest appliance surfaces will show graying or fading. To touch up and restore the appliance's appearance, high temperature (1,200°F) spray paint should be used. Manufacturer's instructions should be followed and adequate ventilation provided. The owner should be advised that some of the smoke and odor associated with paint curing of a new appliance will occur when the appliance is used again.

9.2.1.6 Other Appliance Components

Other appliance components subject to wear and tear include baffles, dampers, secondary air tubes, door latches and handles, firebricks, and thermostatically controlled air inlets. Warping of baffles and air tubes affects performance and calls for replacement. Air inlets on air tubes should be inspected for blockage and cleaned. Latches may need adjustment or replacement; wooden handles eventually scorch and deteriorate and should be replaced. Cracked side (vertical) firebricks may sometimes be swapped with bottom (horizontal) firebricks; otherwise they should be replaced. Thermostats may need adjustment or replacement (manufacturers may instruct the proper position of the air flap at a particular setting and room temperature).

Electrical blowers may need cleaning and/or oiling on a periodic basis. Manufacturer's instructions should be followed.

Use only manufacturer recommended replacement components. This can be a matter or performance and even safety. For example, special tinted glass is used on some woodstoves as part of the system that retains heat in the firebox for EPA certification. Using untinted glass can change stove performance and/or safety (by changing the amount of heat that is radiated out the glass onto the floor).

Even firebricks should be supplied or recommended by the woodstove manufacturer. There are two types of firebricks commonly used in woodstoves. Pumice type bricks (rough and light weight) are used by manufacturers to help insulate and retain heat in the firebox. Fired clay type bricks (smooth and heavy) have a lower insulating capability. Changing firebrick can affect stove performance.

9.3 Appliance Break-in Procedures

9.3.1 Verify the Installation

- Make sure requirements in installation manual have been followed
  - Clearances
  - Venting requirements
- Keep all flammable materials 36" (drapes, furniture, clothing, etc.) away from the front of the stove.

9.3.2 The First Fire

9.3.2.1 Woodburning Appliances

Firebrick, stone, masonry and cast iron all contain moisture that needs to be driven out of a new hearth appliance. Starting with several low-heat break-in fires is the best way to start up the appliance. Your first fire should make the stove warm but not hot, to the touch. Let the stove return to room temperature. Each subsequent file can be a little hotter than the previous fire.

NOTE: Because of the cool flue gas temperatures present during the break-in procedure, creosote may build up quickly. The stove's window may get dirty. A subsequent good, hot fire will clean the glass. We recommend a visual inspection (and cleaning if necessary) of your stovepipe and chimney after the break-in procedure is completed.

The door gasket might adhere to the paint on the front of the heater. Leave the door slightly ajar for the first fire and be careful when opening the door after the first fire.

9.3.2.2 Gas and Pellet Appliances:

Burn the appliance with the blower off for an extended period of time. This will cure the painted surfaces a little faster. It is normal, especially in cold weather climates for condensation to appear on the glass each time you start the stove. Gas flames will tend to be more blue than yellow when the appliance first comes on. After fifteen minutes the flames will normally turn a more realistic yellow and orange color.

9.3.3 Fumes & Paint Curing

New appliances will generally give off fumes and smoke during the first few hours of operation. This is normal with all new appliances. If possible, open doors and windows in the room to ventilate the heater during the curing process. The fumes from the initial heating process are non-toxic but may be unpleasant.

Start the appliance and let it burn for 1 Hour, then open the door. The stove paint is cured through heat to prevent it from bonding to the door gasket. This stove uses a heat-activated paint that will emit some fumes while starting the first fire. Open doors and windows to the room to vent these fumes. You may also notice oil burning off of the interior of the stove which will soon dissipate.

9.3.4 Manufacturer Instructions

Your installation and operation manual contains important information relating to the operation and maintenance of your appliance. Please read the manual and keep it handy.

9.3.5 Warranty

Each manufacturer has their own warranty policy. Most manufactures recommend contacting the selling dealer for warranty service. Be sure to read and follow the manufacturer's instructions in order to maintain the warranty.

9.3.6 Annual Maintenance

Every specialty heating appliance has specific annual service requirements. Follow the manufacturer's instruction carefully and your appliance will function for many years to come. Blowers will be cleaned and lubricated as required.

9.3.6.1 Gas

Clean the firebox, logs, control compartments and vent systems

9.3.6.2 Wood

The chimney should be swept at least once a year. Also clean the firebox and inspect the interior of unit for any cracks, warped pieces or other abnormalities

9.3.6.3 Pellet

Proper maintenance of pellet appliances is critical to ensure their proper operation. The Owner's Manual will list yearly, monthly, weekly and even daily maintenance procedures. Be sure to carefully follow them.

9.4 Recommended Start-Up Service

To the customer:

This service is designed to educate you on proper operation and maintenance of your new hearth appliance. Our expert service technician will come out to your home while you are present and walk you through the operation. The following list of quality checks will be administered to ensure many years of satisfaction with your hearth appliance:

☐ Verify that required clearances to combustibles have been met.
☐ Make sure all furniture, drapes or other materials are at least 36" away.
☐ Touch up painted surfaces if necessary
☐ Remove all protective coatings and labels on glass or brass trim
☐ Clean the glass
☐ Test fire the unit
☐ Provide batteries for remote if necessary
☐ Test all options for proper operation
☐ Explain the general operation
☐ Explain proper break-in procedure
☐ Explain maintenance procedures for glass cleaning and general care
☐ Explain moisture build-up on glass for first few minutes of operation
☐ Fill out and send in warranty card

Gas Appliances

☐ Adjust burner and pilot to manufacturer's specifications
☐ Set up logs properly and install ember or other media
☐ Insulate gas inlet hole
☐ Check for gas leaks
☐ Check Thermopile voltage ________ mV
☐ Check Thermocouple voltage ________ mV
☐ Check Manometer reading ________ W.C.I.
☐ Check Valve ("TH" - "TP") ________ ohms
☐ Check Valve ("TP" - "TH/TP") ________ ohms
☐ Check Venturi (Air Shutter)

We believe this service will be very beneficial in making you comfortable and confident with the operation of your new hearth appliance.

Other notes: ____

____

____

____

Model ______________________ Serial # ______________________

Customer Signature ______________________ Date ____________

Manufacturer's Instructions

For the most part, decisions in planning and installing hearth products are clear-cut. The manufacturer's instructions tell what must be done, what can be done, and what cannot be done. The same is predominantly true with codes and standards. As all experienced hearth professionals know, however, difficult or complex decisions can arise.

Sometimes the difficulty is simply finding the applicable information. That difficulty can sometimes be reduced by downloading the online electronic version of the manual and performing a careful and thorough search for a word or phrase. Every manufacturer organizes the information differently, and the manuals also contain warnings that are necessary and required by product standards.

Installation manuals often include instructions for different applications and situations for the appliance. A number of facing requirements with subtle difference and intricate illustrations may be offered for factory-built fireplace installation. Different choices and prohibitions regarding venting systems may be detailed for a free-standing stove or fireplace insert installation. Venting installation details may depend on different situations. Variations in clearances related to optional heat shields demand close attention. Standard residential and mobile home installation instructions vary. Some instruction manuals may include a number of models that have different dimensions and different requirements. It is therefore critical to make sure that instructions, diagrams, charts, and the like are carefully checked to make sure they apply to the installation at hand.

The same difficulty can be encountered with finding applicable regulations in codes and standards. The codes and standards that contain regulations relevant to hearth systems also contain other products and systems. Typically hearth product regulations are a small portion of the document, often mixed in with other similar products and located in various sections of the document. The index of most codes and standards help in some instances, but in most they are relatively incomplete.

Besides searching diligently and exercising care in making the search comprehensive, there are some tools that can help with codes and standards. For those that find it necessary to refer to them fairly often, digital versions may be worthwhile.

10.1 Product Identification

Make sure that the appropriate instruction manual is used. That means the manual for the specific appliance, not just one of the manufacturer's manuals. It also means checking the manual packed with the appliance to make sure that no changes in instructions have taken place. If the manual is not readily available, most manufacturers post their installation manuals on their web page.

Installation manuals often include instructions for different applications and situations for the appliance. The manual may include:

- a Type B vent and a direct vent version of the same model
- a gas log set may have a dual listing for vented and unvented applications
- a unit may have instructions for installation as a freestanding stove or fireplace insert
- more than one model, with important differences in dimensions and requirements, may be included in one manual
- requirements for the US and Canada, which often differ, may be given together or side by side in charts
- different venting configurations may have different clearances
- standard residential and mobile home installation instructions vary
- the appliance manufacturer may defer to approved venting manufacturers' instructions or, particularly for direct vent, require that their own configurations and clearances included in the appliance instruction manual be followed.

It is therefore critical to make sure that instructions, diagrams, charts, and the like are carefully checked to make sure they apply to the installation at hand.

10.1.1 Label and Listing

The instructions may include a sample label that includes listing information, EPA status, basic minimum clearances information and diagrams, and more that appear on the permanent label attached to the appliance. The listing information, safety lab where the model was tested, and EPA information (certified or exempt) also appear elsewhere in these first pages. In addition, appliances tested and listed for installation in mobile homes is included and specific requirements will be included in a section later in the manual.

10.2 Safety Warnings and Notices

Safety notices and warnings caution the installer and user to read the entire manual before installation and use and warns that failure to follow the instructions can result in property damage, bodily injury, or even death. Those grim words are required to be included by the appliance safety standard; they reflect the reality that those results have occurred and could again. Homes and lives are in the hands of hearth professionals.

Most, if not all, of the many warnings and notices that appear in bold letters and in text boxes throughout the manual are specifically required by the appliance safety standards. The intention is clearly to underscore the importance of these subjects and the gravity of decisions and actions regarding them. The repetition and the sheer quantity of them may unfortunately have an unintended numbing effect that leads to inattention. Like driving a vehicle, close attention to and awareness of these messages should be emphasized. It may be worthwhile to implement an exercise such as highlighting (in different colors perhaps to distinguish between those for installers/planners and users) every notice and warning at regular intervals and for every new product.

10.3 General Instructions

As mentioned previously, a manual may serve for more than one model and have some different requirements or specifications for the models. There may be US and Canadian requirements that differ. These differences may be bold and in text boxes or be less obvious in footnotes. There is usually a reference to installation work being performed only by qualified personnel. Many appliance and vent manufacturers include language recommending or suggesting installation by NFI Certified Specialists.

In addition to the ultimate deciding factors (minimum clearances, vent location, and customer preferences), instruction manuals include reminders for appliance placement out of traffic and away from furniture and drapes.

10.4 Clearances

It is important to keep in mind the rationale for and importance of the manufacturer's minimum clearance requirements: the appliance has undergone rigorous testing according to an accepted safety standard that is intended to ensure that nearby combustibles will not ignite from heat from the appliance, even as these combustibles, which may be concealed from sight, dry out and have lower ignition temperatures. That means in every case that the minimum airspace distance in the instructions must be met or exceeded.

Careful attention must be paid to the charts and diagrams provided, including those that show the dimensions of the appliance and position of the vent. Points of measurement may vary for US and Canadian requirements. They may also vary for different parts of the stove; for example, front and side clearances measured from the stove top, while rear and corner clearances must be measured from the stove body.

Instructions often refer to industry standards for clearance reduction beyond the listed clearances, but those methods can NOT reduce appliance clearances to less than 12 inches. If it is possible to use the reduction methods, the calculations of the reduction percentages should not be rounded up.

The manufacturer may provide minimum dimensions, including ceiling height recommendation or requirement for alcove installations. Finally, instructions often recommend providing greater distances than the minimum clearances for convenient operation and service.

10.5 Venting

As a hearth professional, you recognize the importance of proper venting in ways that many customers will not. The installation instructions offer a number of choices and a significant amount of information about the different aspects of venting that we break down below.

Venting terminology is not always consistent in installation manuals. But the important fact is that the vent is tested and listed by each manufacturer. Each brand and model may have some different requirements, so mixing of different product brands is not approved.

Another issue related to product identification is the source of installation requirements. Although some appliance installation manuals may indicate that the vent should be installed according to the vent manufacturer's instructions, the same manual may indicate pipe clearance and termination requirements that must be followed.

Manufacturer's vent installation instructions use diagrams and text to indicate preferred locations in relation to the position of the vertical roof termination, location of trees and other obstructions, prevailing winds, etc. Obviously, the layout of the house, customer preference, and other factors play into these decisions.

The instructions give maximum vertical height, maximum horizontal run, maximum vent length, maximum turns, and more. For both locations and configurations, the instructions may label the options as preferred, marginal, or not recommended. Professional experience and judgment can play a significant role in customer satisfaction.

A line drawing of a house exterior with letters keyed to a long list of termination requirements is typical of most installation instructions. Using the diagram and list involves careful assessment of desired termination locations. A check off process eliminating requirements that do not apply may be worthwhile. Care must be taken in the process to distinguish carefully between similar situations (eg., ventilated vs. unventilated soffits, inside and outside corners), footnotes (eg. termination under a porch or deck only if at least two sides are open), variations in local or Canadian regulations, or a bolded note for any difference in clearances when outside air is installed.

Vent manufacturer's instructions may provide reduced termination clearances based on a direct vent system providing all combustion air from outdoors, but those instructions may also include mechanical vent termination requirements in the event that an AHJ does not interpret the installation as direct vent.

Sample installation manual

Page one

Rear Wall Vent Installation

Twist Lock Pipe

Locate and cut the vent opening in the wall.

NOTE: When using flex vent, the pipe must have a vertical rise of 1" in 24" of horizontal run.

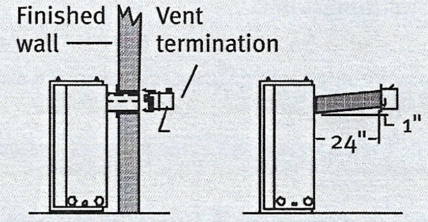
It is critical that there is no downward slope in the vent pipe.

Example 1: *If the centerline of the appliance flue outlet is 32", what is the minimum height for the centerline of the opening in the wall if the rear of the appliance is 12" from the rear wall and rigid pipe is used?*

32"

Sample installation manual

Page two



Rigid pipe installation **Flex pipe installation** min. rise 1" in 24" run

Example 2: *If the centerline of the appliance flue outlet is 32", what is the minimum height for the centerline of the opening in the wall if the rear of the appliance is 12" from the rear wall and flex pipe is used?*

32 ½" (Must have 1" rise in 24" = ½" rise in 12". 32 + ½ = 32 ½)

10.6 Outdoor Combustion Air

Outdoor air provided directly to the appliances is required for mobile home installations except when installing a direct vent gas appliance which brings all of its combustion air in from the outside. Some manufacturers require this feature for all installations, while others may recommend, but not require it for conventional houses. In all cases, the instructions indicate requirements for location and configuration, including avoiding plugging by snow or other materials.

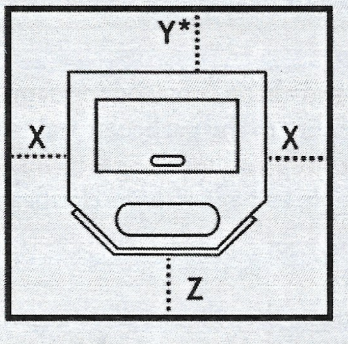
10.7 Owner/User Information

It is advisable to be familiar with all the sections directed at the new user of the system in order to explain and demonstrate the system, as well as respond to questions and problems after installation. This includes sections on:

- Operation
- Fuel
- Maintenance
- Troubleshooting
- Warranty

And finally, it is important to follow one of the first directions in installation manuals: leave the manual for the owner.

Instruction manual example



Hearth Pad Requirements

		inches	mm
X	Sides	2	51
Y*	Back	2	51
Z	Front	6	152

*Vertical vent installations only.

Noncombustible floor protector is required to extend beneath horizontal flue pipe or under the top vent adapter in Canada, in the U.S. it is recommended.

Question 1: What is the difference between floor protector specifications for this unit in the U.S. and Canada?

Question 2: If the depth of the unit is 28", what is the minimum depth of the floor protector in the U.S.?
34" In Canada? 36"

Question 3: From what point on the front of the appliance that floor protection must extend measured?
Point L, the surface of the glass door.

10.8 Instruction Manual Examples

10.8.1 Attention to Details

Once the appropriate and relevant requirement is found and confirmed, it is important to pay close attention to details and exceptions. Such variations may be highlighted in a note or warning, they may be marked by asterisk (*), they may be called out in an illustration, or they may simply require careful reading.

Situation #1

Model	Front	Back width*	Depth width**	Height	Min. vent opening***
A 18"	28	16	14	18	7" dia.
B 24"	30	18	16	18	8" dia.
C 30"	36	26	18	18	8" dia.

*Add 6" if safety pilot is used (required for propane gas models)
**Measured at minimum depth
***Or flue at least 1/10 of fireplace opening

Example 1. Factory-built fireplace 36" wide at front, 22" wide at 18" deep, 23" high; 8" diameter flue.

For which models is the flue size adequate?

8" diameter chimney meets or exceeds requirements for A, B, C.

Which models, burning propane, can be used in this fireplace?

A and B. C is unacceptable because the minimum dimension is 36 + 6 (*additional for safety pilot required on propane models).

Which models, burning natural gas without a safety pilot (where allowed), could be used in this fireplace?

A, B

Example 2. Masonry fireplace 36" wide at front, 28" wide at 18" deep, 26" high; 8½ x 13 non-modular flue liner (74 square inches).

Which of the models can be used in this fireplace?

None, because the flue area is less than 10% of the fireplace front area (36 x 26 = 936 x 10% = 93.6 square inches required minimum flue area).

Situation #2

Appliance: direct vent built-in fireplace, 2 models, X and Y, in one manual, both 44" tall firebox with 4" standoffs on top

Manual Language (note: for Model X only): When venting with a 3-foot vertical section and a 90° elbow as the first two vent components, the noncombustible zone is the entire width and depth of the firebox from the top of the fireplace to 3" above the horizontal vent. This area must remain free of combustibles.

Example 1. *If Model X is installed on the floor, what is the minimum height above the floor that combustible framing or sheathing can be applied if the height to the top of a 3-foot vertical section with a 90° elbow is 47"?*

94" (44 + 47 + 3 = 94)

Example 2. *If Model Y is installed on the floor, what is the minimum height above the floor that combustible framing can be applied?*

48" (44 + 4 [height of standoff] = 48)

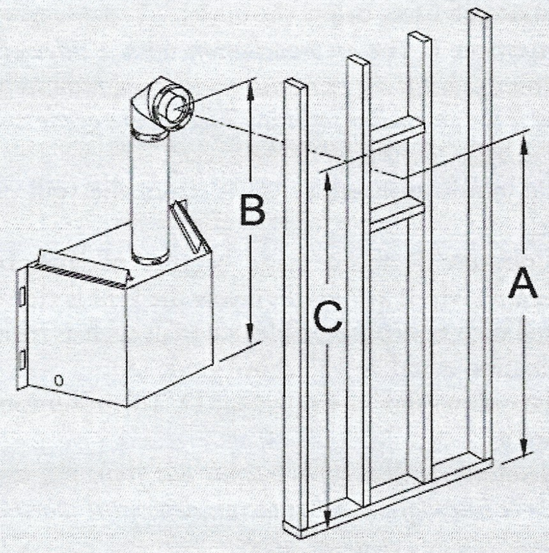
10.8.2 Correct Interpretation and Calculation

Often the ultimate challenge is interpretation of the language or of illustrations, diagrams, and charts provided in manufacturers' instructions. The problem may be lack of clarity and specificity, or it may be applicability to the particular real world situation at hand. Communication with the manufacturer's technical support can usually clarify and resolve problems, but if verbal communication appears to be at odds with printed instructions, it may be advisable to have written clarification faxed or mailed.

10.8.3 Illustrations and Diagrams

Although most illustrations and diagrams clarify text and assist greatly in interpreting language, they require close attention to detail and can cause confusion. Close attention to notes and asterisks is important here also. In addition, careful attention must be paid to points of measurement, the exact places where measurements are taken. For example, some vent measurements may be given from the centerline of the pipe while others are given from the outside of the pipe. Also keep in mind that fractions of an inch cannot be rounded up. For example, for a minimum vent clearance of 3 inches, a clearance of 2 3/4 inches is NOT acceptable, but 3¼" is.

The type of illustration for sidewall terminations is generally accompanied by numerous requirements linked to letters



Example 1: center of framing hole* for venting

The center of the hole is 1" above the center of the horizontal vent pipe.

*Minimum framing hole size:

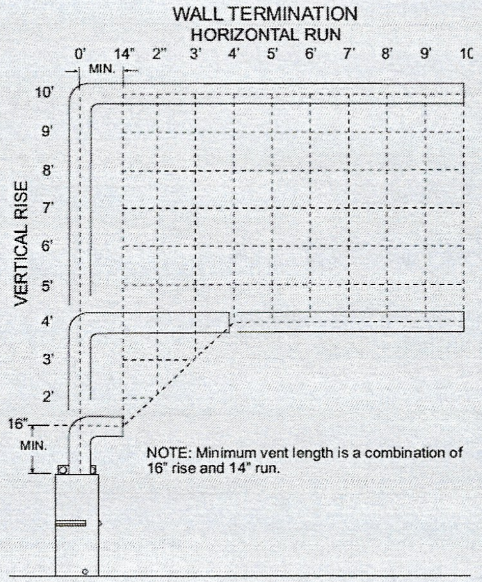
Model X 12" h x 12" w.	Model Y 12" h x 10" w.
A. Model X: 86"	B. Model X: 85"
A. Model Y: 88"	B. Model Y: 87"

Question 1. *For model X, what is the minimum height above the floor for the bottom of the top header of a minimum sized framing hole, represented by C?*

92" (86 [to hole centerline, A] + 6 [half of framing hole minimum height] = 92).

Question 2. *For model Y, what is the width of a minimum sized framing hole?*

10".



NOTE: Minimum vent length is a combination of 16" rise and 14" run.

Example 2

Question 1. *What is the maximum horizontal run allowed by the chart?*

10' (with 10' rise)

Question 2. *What is the maximum vertical height allowed by the chart?*

10' (with minimum 14" run)

Question 3. *Is a configuration with a 3' rise and 4' run acceptable?*

No (outside of chart: run too long)

Question 4. *What is the minimum rise required for any run greater than 4'?*

4' (anything less falls outside chart)

marking different situations. The examples here are for instructional purpose only. The appliance manufacturer's instructions and/or approved code requirements are the proper sources for such information.

A. The clearance above grade must be a minimum of 18"

B. The clearance to a window or door that may be opened must be a minimum of 48" to the side and 48" below the window/door, and 18" above the window/door.

C. A 12" clearance to a permanently closed window is recommended to prevent condensation on the window.

D. The vertical clearance to a ventilated soffit located above the terminal within a horizontal distance of 2 feet from the centerline of the terminal must be a minimum of 18".

E. The clearance to an unventilated soffit must be a minimum of 12".

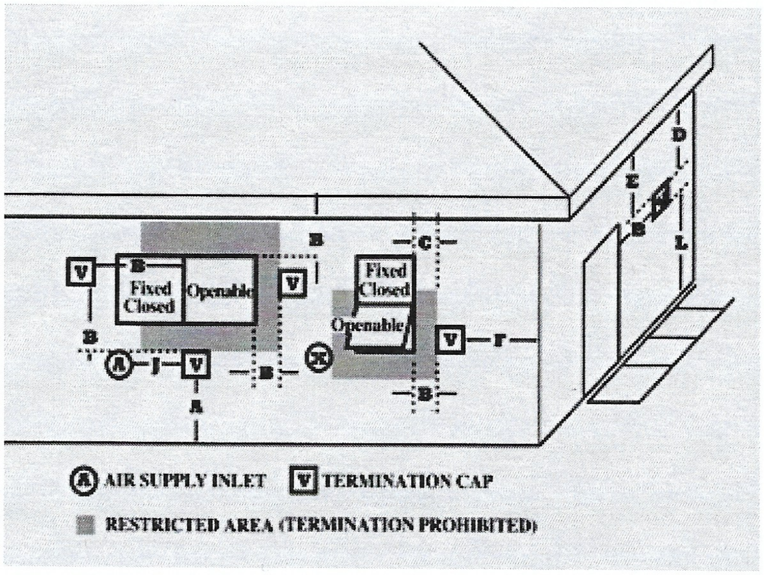
F. The clearance to an outside corner is 11".

G. The clearance to an inside corner is 12".

H. A vent must not be installed within 3 feet above a meter/regulator assembly when measured from the horizontal centerline of the regulator.

M. The clearance under a veranda, porch, deck or balcony must be a minimum of 12".

NOTE: The clearance to vegetation and other exterior combustibles such as mulch is 36" as measured from the center of



the outlet or cap. This 36" radius continues to grade or a minimum of 7 feet below the outlet.

Question 1. *For an installation with a sidewall termination, what is the minimum and maximum terminal height if the ventilated soffit is 12 feet above grade and the lawn extends to the wall of the house?*

The termination outlet is 18" from the wall of the house.

Minimum 7' above grade because of lawn below (Note after M). If a 3' radius below the vent is cleared or covered with noncombustible materials such as rock, the termination could be 18" above grade (A).

Maximum 10½' above grade (D: 18" minimum below soffit).

Question 2. *If a deck extends out from the wall in the above installation, what factors determine whether the terminal can be below the deck?*

Area below deck must be fully open on at least 2 sides (M, footnote 31).

Clearance under deck to terminal must be at least 12" (M).

Clearance from grade to terminal must be at least 18" (A).

A minimum 36" radius from the terminal to grade must be clear of vegetation and other exterior combustibles (NOTE after M).

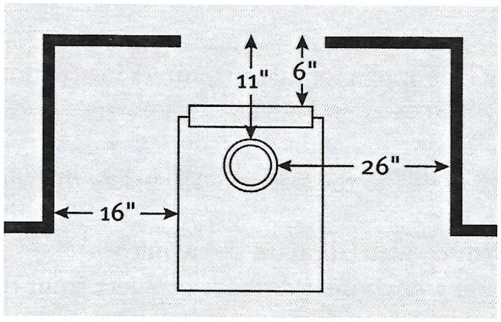
Question 3. *What is the minimum distance between the side of an openable window and an inside corner of the house that would allow installation of pellet vent that is 3 5/8"OD?*

Minimum 63 5/8": B. 48" from side openable window + 3 5/8" OD of pipe + G. 12" from inside corner

Calculation. Occasionally manufacturers' instructions require basic calculation. That can be as simple as adding total vent horizontal length, vertical height, and numbers of elbows to make sure that an intended venting configuration is within the parameters of the appliance manufacturer's specifications.

For the most part, decisions in planning and installing hearth products are clearcut. The manufacturer's instructions tell what must be done, what can be done, and what cannot be done. The same is predominantly true with codes and standards. As all experienced hearth professionals know, however, difficult or complex decisions can arise.

*NOTE: Alcove dimensions cannot be reduced by the use of noncombustible materials such as brick, stone, metal, etc. Alcove dimensions are minimum dimensions, not measurements for constructing an alcove.



Question 1. *If the appliance is 24 inches wide, what is the minimum width for an alcove with combustible side and back walls?*

56 inches (16 + 24 + 16 = 56)

Question 2. *What is the minimum width for the alcove if NFPA 211 compliant ventilated masonry (66% reduction of clearances) protects the side and back walls?*

56 inches because the note prohibits further reduction of clearances

Question 1. *For an installation at 2,500 feet elevation with two 30° elbows, what is the minimum recommended flue height?*

16.2 feet (see table next page).

Question 2. *For an installation at sea level, how much taller does the flue have to be with two 30° elbows than it does for two 15° elbows?*

2 feet (15 13 = 2)

Example 2.

Question 1. *A combustible wall bookcase projects 7¾" from the wall beside the fireplace. What is the minimum distance that the bookcase must be from the fireplace opening?*

10" (see illustration next page)

Question 2. *How far can the legs of a combustible mantel that butts up to the side of the fireplace project from the wall?*

1¾" (which is 2" from the fireplace opening)

Calculation. Occasionally manufacturers' instructions require basic calculation. That can be as simple as adding total vent horizontal length, vertical height, and numbers of elbows to make sure that an intended venting configuration is within the parameters of the appliance manufacturer's specifications. Or it may involve percentages and/or fractions.

Example 1 fractions. Manufacturer's instructions call for ¼" per foot rise for horizontal vent sections. If the center line of the appliance flue outlet is 28" and the horizontal distance from the appliance to the wall is 17", what is the height of the centerline of the wall opening?

Minimum recommended flue heights in feet
(Measured from the top of the solid fuel appliance)

Elevation (ft) above sea level	Number of elbows						
	0	2 X 15°	4 X 15°	2 X 30°	4 X 30°	2 X 45°	4 X 45°
0 – 1,000	12	13	14	15	18	16	20
1,000 – 2,000	12.48	13.52	14.56	15.6	18.72	16.64	20
2,000 – 3,000	12.96	14.04	15.12	16.2	19.44	17.28	21.6
3,000 – 4,000	13.44	14.56	15.68	16.8	20.16	17.92	22.4
4,000 – 5,000	13.92	15.08	16.24	17.4	20.88	18.56	23.2
5,000 – 6,000	14.4	15.6	16.8	18	21.6	19.2	24
6,000 – 7,000	14.88	16.12	17.36	18.601	22.32	19.84	24.8
7,000 – 8,000	15.36	16.64	17.92	19.2	23.04	20.48	25.6
8,000 – 9,000	15.84	17.16	18.48	19.8	23.76	21.12	26.4
9,000 – 10,000	16.32	17.68	19.04	20.4	24.48	21.76	27.2

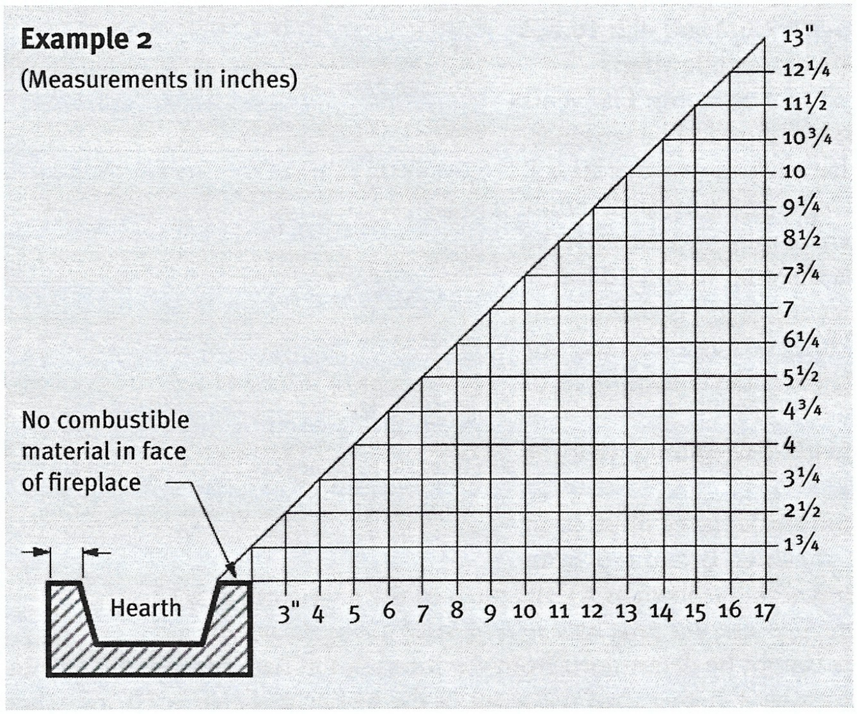
Step 1. Convert horizontal inches to feet: 17 ÷ 12 (inches in 1 foot) = 1.42 feet

Step 2. Convert inches fraction to decimal: 1 ÷ 4 = .25

Step 3. Multiply inches per foot rise times horizontal feet: .25 x 1.42 = .355 inches rise

Step 4. Add rise to flue outlet height: 28 + .355 = 28.355"

Step 5. For convenience, round up to easily measurable distance that exceeds the minimum: 28½" or greater.


Example 2
(Measurements in inches)

10.8.4 Interpreting Codes and Standards

Finding and interpreting details of lengthy regulations can be time consuming and challenging. We have offered examples of different types of difficulties with exercises that demonstrate approaches and solutions. We have also talked about the relation between code authorities, different regulations, and manufacturers' requirements.

The process begins with making sure that the relevant code or standard is being used. That can include confirming recognition of the regulation by the local, county, and/or state authority having jurisdiction (AHJ) the recognized edition (date and local/state amendments) reference to the regulation by the manufacturer.

Then the process involves finding the proper section(s) of the document, such as combustion air requirements for a vented gas appliance or location requirements for a shutoff valve.

It is a good idea to "backtrack" to confirm that the section applies to the situation at hand. This means going from a code sub-section back through higher sub-sections and back to the section or even chapter to confirm the relevance. For example, NFPA 211 section 7.1.4.1 calls for cleanout openings to be provided in all chimney flues serving freestanding appliances. It is necessary to understand the number system and trace this sub-section back to the chapter heading, Chapter 7 Masonry Chimneys, in order to understand that this requirement does not apply to factory-built chimneys (covered in Chapter 6, which does not have a cleanout opening provision).

Great care must be exercised in paying close attention to detail. Code language is sometimes not user friendly, but the intention is precise language that reduces individual interpretation. One aspect of attention to detail is also a part of finding relevant regulations: following references to other sections.

Example 1. NFGC 9.7.1 prohibited installations

"Vented gas fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with 9.3.2."

By itself, this section seems to single out bedrooms and bathrooms as spaces that must be large enough (have sufficient volume) to provide sufficient combustion air. But 9.3.2 Indoor Combustion Air includes the provision that:

"Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with 9.3.2.3 are considered a part of the volume."

This section clarifies the previous one: the bedroom or bathroom is acceptable if its volume and, if needed, directly communicating spaces or other rooms connected by approved air openings (found in 9.3.2.3) provide sufficient volume according to the code.

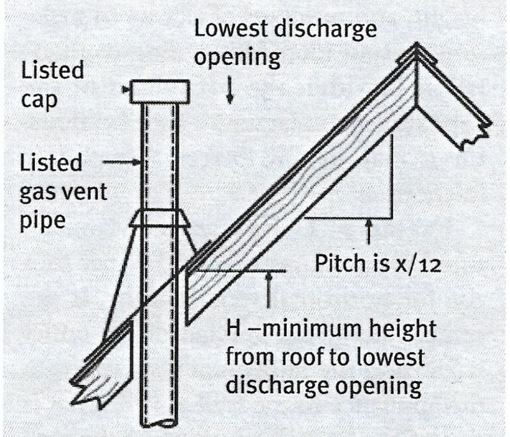
Example 2. IFGC-00 and -03: 503.6.6. NFGC-99: 7.6.2 and -02: 10.6.2

A gas vent shall terminate in accordance with one of the following:

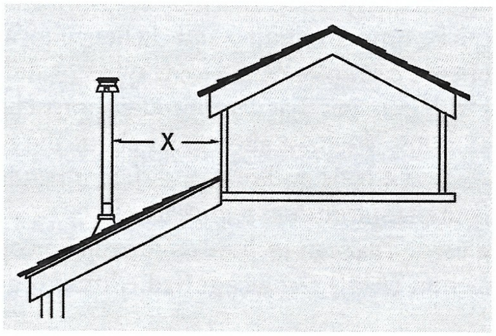
"Above the roof surface with a listed cap or listed roof assembly. Gas vents 12 inches in size or smaller with listed caps shall be permitted to be terminated in accordance with the figure below, provided that such vents are at least 8 feet from a vertical wall or similar obstruction. All other gas vents shall terminate not less than 2 feet above the highest point where they pass through the roof and at least 2 feet higher than any portion of a building within 10 feet."

This regulation may not apply if manufacturer's instructions define vent termination. But some manufacturers cite NFGC or IFGC as a reference for conventional vent termination. In any event, it illustrates the convolutions of code language and details.

A logical process to unravel the language starts with determining what the regulation covers.



Roof pitch	H minimum	
	feet	meters
Flat to 6/12	1.0	0.30
6/12 to 7/12	1.25	0.38
Over 7/12 to 8/12	1.5	0.46
Over 8/12 to 9/12	2.0	0.61
Over 9/12 to 10/12	2.5	0.76
Over 10/12 to 11/12	3.25	0.99
Over 11/12 to 12/12	4.0	1.22
Over 12/12 to 14/12	5.0	1.52
Over 14/12 to 16/12	6.0	1.83
Over 16/12 to 18/12	7.0	2.13
Over 18/12 to 20/12	7.5	2.27
Over 20/12 to 21/12	8.0	2.44



Example 3. In the illustration at left, the listed B vent is 6' from the vertical wall (shown as X).The pitch of the lower roof is 5/12.

How high does the vent have to terminate above the lower roof?

This cannot be determined from the information here because the termination must be 2' higher than the point of the higher roof that is 10' away horizontally from the vent.

If the B vent were 8 feet from the vertical wall, how high does the vent have to terminate above the lower roof?

1' (from the illustration here and chart on the previous page).

10.9 Authority Having Jurisdiction

NFPA 211 recognizes the Authority Having Jurisdiction (AHJ) as "An organization, office, or individual responsible for enforcing the requirements of the code or standard, or for approving equipment, an installation, or a procedure." AHJ can be at different levels of government (federal, state, local), representing different departments and functions (fire chief or marshal, health inspector, building official). In some circumstances, the property owner or designated agent functions as the AHJ.

NFPA 211 and IRC are consistent in recognizing the fundamental responsibility of the AHJ enforcing the provisions of the code. In addition, IRC recognizes the right of the AHJ, within limitations, to make modifications in the event of practical difficulties and as long as the intention and protection of the code are followed and both NFPA 211 and IRC grant the AHJ, who is designated by the governing authority, to approve, with substantiation of safety, equivalent materials, construction methods, or installation procedures. The 2010

NFPA 211 establishes the right of the AHJ to require tests showing proof of equivalency.

In practical terms, it is the AHJ that typically makes final interpretations and decisions. An appeal process normally resolves serious conflicts over code decisions.

10.10 Codes and Standards

10.10.1 Local Codes

Some states make amendments or additions to codes and publish state versions of the codes. Local jurisdictions may also have additional requirements. The fuel gas codes provide for and set some parameters for such modifications.

Some jurisdictions do not adopt an applicable code or do not enforce code requirements. Manufacturers' instructions, however, typically call for adherence to one of the national codes. Most importantly, however, for customer safety and defensible liability, it is always advisable to follow both manufacturers' instructions and national code requirements to the letter.

10.10.2 Referenced Standards

The fuel gas codes list other standards that cover areas related to the main focus of the standards. In some cases, the fuel gas code refers to a specific standard within the code to assign responsibility for a specific topic. IRC stipulates that its provisions apply where there are differences in the referenced standards.

10.10.3 Applicability and Retroactivity

NFPA 211 and IRC do not call for the provisions of the current code to be applied retroactively to existing systems that were in compliance with the provisions of the code that was in effect at the time of installation.146

Many jurisdictions lag slightly or far behind current editions of the codes. There may be cases where a planner or installer would prefer to follow regulations from a newer version than the currently adopted version of the code. If the newer provision is stricter than the current one, there should be no problem in exceeding the demands of the current edition. If the new provisions are less strict or substantially different from the current edition, it would be necessary to seek approval from the AHJ.

10.10.4 Recognition of Manufacturers' Instructions

IRC defers to the manufacturers' instructions of listed products. IRC specifically states "Where enforcement of a code provision would violate the conditions of the listing of the equipment or appliance, the conditions of the listing and the manufacturer's instructions shall apply."

NFPA 211 does not state this principle directly, but throughout the standard references manufacturer's instructions of listed equipment.

10.10.5 Conflicts in Requirements

The wide variety and complexity of appliances, venting systems, construction, and other factors results understandably in gray areas where manufacturers' instructions, code requirements, and AHJ interpretation are either in conflict or not entirely applicable to a particular situation. As noted above, if the conflict is between manufacturer's instructions for a listed, tested product, usually the manufacturer's requirements prevail. Where there is involvement of the AHJ, generally his/her interpretations prevail, though they may be subject to appeal through a formal process.

In cases where there is conflict or ambiguity about a requirement, one path to resolution is to accept and carry out the strictest choice. For example, IRC allows exterior air intake for a fireplace to be taken from a non-mechanically ventilated attic, but the air intake cannot be "located at an elevation higher than the firebox."148 There can be situations where an attic air intake could be lower than the firebox (an installation on a kneewall with attic space behind it in an upper story of a house), but in most situations these requirements are in conflict.

Consultation with the AHJ might solve such a conflict, but if not it is best In such situations to make sure that the stricter choice is made (here to avoid air intake in an attic above the fireplace). For situations that involve a minimum, the larger number is stricter. For maximum situations (such as the distance a shutoff valve can be located from an appliance), the smaller number is stricter.

11.1. Product Knowledge

A systematic, logical approach to troubleshooting can save time and effort. The starting point for all troubleshooting is extensive knowledge. That knowledge must include:

- **Background fundamentals.** The technician must bring broad ranging technical knowledge to bear on the problem, including principles of combustion, venting, electricity, mechanics, measurement, safety, and more. In addition, the technician may find principles of communication with owners valuable.
- **System Interaction.** Knowledge of the operational principles of the hearth system (appliance and venting system) can provide important clues and shortcuts. The house and its environment may have to be considered as part of the system in some situations.
- **Product Specifics.** Knowledge of the technical specifications provided by the appliance/venting manufacturer are absolutely essential in most troubleshooting procedures. Care must be taken to know or find the information specific to the brand and model.
- **Information Resources.** With experience, the technician carries more and more of the information in memory. But regardless of experience and expertise, there is always a situation that calls for additional resources. The resource may be printed, such as the owner's manual, the manufacturer's service guide, a technical bulletin, or a reference manual such as this one. Or it may be electronic, such as internet resources. Or it may be human, including a colleague, a manufacturer's technical resource person, or a building or code official. It can be as important to know where to turn for information as to possess information.

11.2 Information Gathering

Armed with extensive technical knowledge, the technician begins the first challenge of sorting out the specifics of the case at hand. Gathering as much information as possible is an investment of time that can reduce frustration and save more time and money. Sources of information include anyone who has spoken to the customer having the problem, documentation of product and installation details, review of product installation instructions, service manuals, and technical bulletins, and of course, the customer and anyone in the household familiar with operation of the appliance. Asking good questions and listening carefully are important skills. In general the information gathering process follows a course that includes answers to questions that include:

- What is happening and in what way is it a problem? The goal of the question is to determine symptoms, that is, what the appliance does that the customer considers abnormal.
- When did the problem start? The goal here is to begin to pinpoint the origin of the problem and the circumstances surrounding a change in performance.
- Had any changes occurred in the operation, fuel, weather, house between the appliance operating properly and the beginnings of the problem? Information about these kinds of changes may provide clues in the later diagnosis.
- Under what circumstances does the problem occur? It may be important to determine whether the problem is consistent, though not related to unusual circumstances; consistent and related to specific circumstances; or sporadic and unpredictable.

11.3. Identifying and Isolating the Problem

The next part of the troubleshooting process is making sure what the problem is and narrowing down the possible causes-before a decision is made about the cause or a remedy is attempted. In some cases, the information gathered will be sufficient to identify the problem. In others, operating and observing the appliance may be necessary. Going through the normal operational sequence seeking an abnormal occurrence can make the problem clear enough to proceed to the next step, isolating possible causes.

The next goal is to eliminate improbable causes and re-focus on a narrowing list of suspects. The most efficient method is to first attempt to isolate the part of the system that is experiencing the problem. For gas hearth appliances, that means thinking of the problems associated with the pilot, the burner, the appliance and its accessories, and the venting system (see below for lists of associated problems).

When the component or part of the system is identified, there is still another thinking process to go through before taking action. The next question is which of the elements necessary for combustion is missing or inadequate. Being reasonably sure of the part of the system that is performing abnormally and tracing the problematic element — heat, oxygen, or fuel — should lead to the best approach for attempting the repair.

11.4. Diagnosis and Repair

With good background knowledge, as much information as possible about the case at hand, and after preliminary elimination and focusing, the technician heads for the root cause and solution. Hands-on troubleshooting and repair call for careful safety procedures, including turning off gas and electricity to the unit. The logical process for deciding what the source of the problem is and what the likely corrective action will be is from the simple to the complex, from the easy to determine and the easy to fix to the more difficult. Confirmation from gauges and tools such as a multimeter, pressure gauge, or electronic sniffer is sought. An important principle in diagnosis and repair is changing only one element and re-checking to isolate the needed repair, to avoid unnecessary repair, and to avoid the confusion that might result from new problems.

11.5 Documentation

Creating or adding to the history of the appliance can make future service or answering questions about service easier. Proper documentation can also protect the technician and his company in legal disputes.

Chapter 12 Basic Electricity

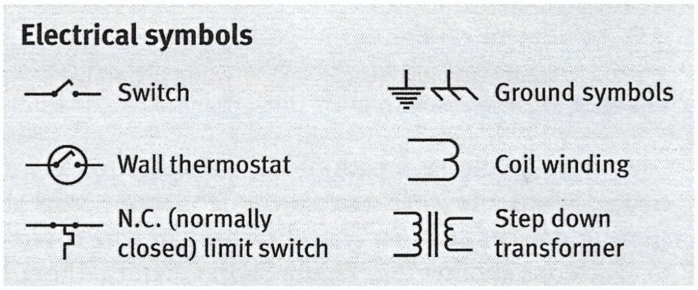
Caution Danger

Take care to avoid severe electrical shock when testing electrical circuits.

Many hearth appliances use electricity to operate various controls and components. Thorough knowledge of electrical principles and safety procedures is essential for anyone working with electricity since it is a potential source of great danger. The goal here is to provide introductory familiarity with basic electrical terminology and principles. A basic understanding of how electricity works and how it can be tested is an essential part of professional knowledge. We offer here a very brief treatment of theory and background information regarding electricity, along with common terms and formulas. We then introduce very basic information concerning equipment and procedures for common electrical testing related to pellet hearth appliances.

12.1 Background and Theory

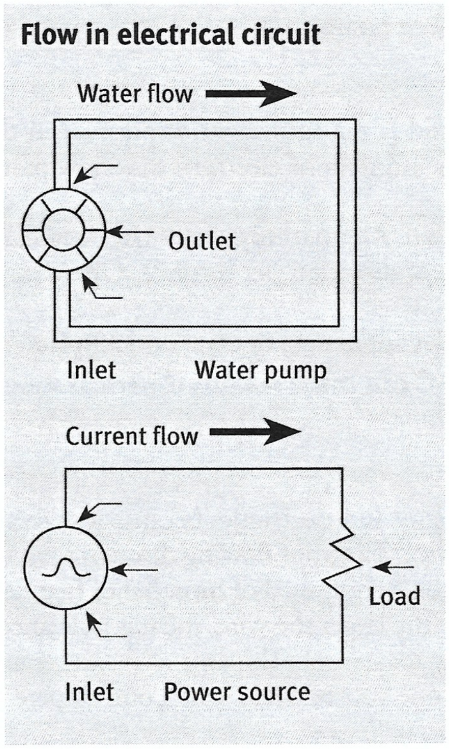
Understanding electricity begins with its definition: the flow of electrons. To understand this definition, we recall that matter (anything that takes up space and has weight) can be broken down into a series of progressively smaller units. Some forms of matter are compounds, which are combinations of more basic forms, elements. Elements can be divided further into atoms, and one part of atoms is electrons. The directed flow of these subatomic particles is electrical current.


Electrical symbols

A conductor is a material that offers very little resistance to the flow of electrons. Materials like aluminum, copper, gold, and silver have electrons that easily leave their orbit and move from atom to atom (known as free electrons). Substances with fewer free electrons, like lead and tin, are poor conductors because they have fewer free electrons per atom. Substances with no free electrons, like glass and rubber, do not normally conduct electricity.

The path through which the electrons flow is an electrical circuit. In pellet appliances, wires and electrical components make up the circuit through which electricity flows. To complete the circuit, electricity must flow or return to its point of origin. To illustrate this concept, compare the flow of electricity to the flow of water in the figures here.

In the closed water system, flow is possible only if water being pumped at the outlet returns to the inlet. Similarly, the flow of electrons requires that they return to their point of origin in an electrical circuit.


Flow in electrical circuit

12.2 Electrical Circuits

The characteristics of the flow of electrons (their force, number, and the resistance they encounter) through their path along wires and components are the basis for electrical testing. Knowledge of the types of circuits and meaning of the characteristics of electrical current help make these tests more understandable.

12.2.1 Circuit Status

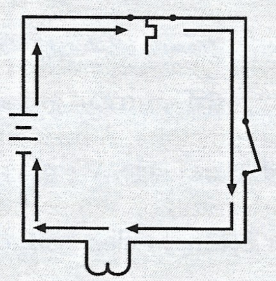
Under normal conditions, electrical circuits either enable electrons to flow from the source and back to it or they prevent such flow. It is important to know the terms that are used for these conditions:

Closed (Complete) Circuit. Current flows from the electrical source and returns to the electrical source. An electrical switch that is closed allows current to flow through and provide power to a connected device.

Open Circuit. Current flows from the electrical source, but is not allowed to return to the source. An electrical switch that is open receives the current flow, but does not allow it to flow farther.

An open circuit is an incomplete circuit. The figure shows an open circuit that will become a closed circuit once the switch is closed. A circuit can also become open when a lead is cut, when one of the wires is removed from a terminal, or when there is a loose connection.

Series circuit

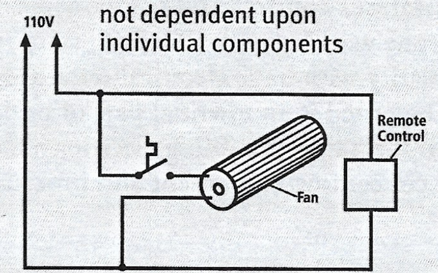


Voltage must flow through each component to complete the circuit

Used in safety circuits

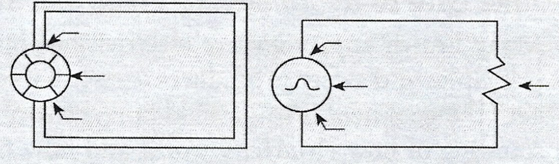
Parallel circuit

Complete circuit is not dependent upon individual components

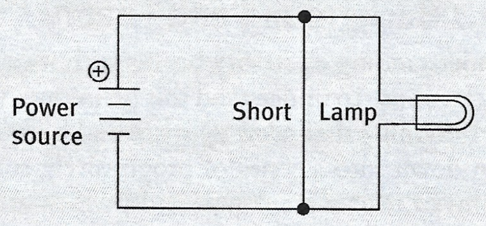


Accessories are usually wired in parallel

Open circuit



Short circuit



A short circuit has a path of low resistance to electron flow, usually created when a low-resistance wire is placed across the power consuming device, as when frayed or broken wire covering allows wires to touch one another (See Figure Short Circuit). The current follows the path of least resistance, through the touching wire rather than through the consuming device. A short usually generates an excess current flow that can damage parts of the circuit or overheat and cause a fire.

12.2.2 Types of Circuits

Wiring circuits are connected in series or parallel. A series circuit requires that the current must pass through each component before it flows to the next component.

A parallel circuit allows electrical flow to pass through alternate pathways to complete the circuit. The flow can pass through or bypass a component.

12.3 Characteristics of Electrical Current

Electrical circuits are tested by measuring force (voltage), resistance (ohms), and current (amperage).

12.3.1 Force

The force that causes electrons to flow is known as an electromotive force (emf) and is the equivalent of pressure in the movement of water. This force or pressure is measured in volts, which represent the number of electrons that flow past a point in a conductor that has a certain resistance (see below).

Voltage is expressed in terms of the kind of current, direct or alternating, being used. Alternating current (AC) regularly reverses its direction (in the U.S. and Canada, 60 cycles (or Hertz) of two changes of direction per second). Operational Electronics also rely on AC power.

Operational controls, motors, and blowers on any appliance operate in most pellet appliances operate on 120 volts AC (VAC). **Safety Warning: Great care must be taken in measuring voltage. 120 VAC can cause serious electrical shock.**

Direct current (DC) always flows in one direction.

12.3.2 Resistance

Movement always encounters resistance, or opposition. Resistance is useful in electricity and electronics because it makes it possible to generate heat, control electron flow, and supply the correct voltage to a device. Electrons flowing through a circuit encounter resistance. The amount of resistance depends on the materials the conductor is composed of (number of free electrons per atom) and the length (the longer, the more resistance), cross-sectional area (the larger the wire, the less resistance), and the temperature (for most materials, the higher the temperature, the greater the resistance). The unit of measurement of electrical resistance is the ohm: the resistance which will cause a voltage drop of one volt to occur when one ampere of current flows through it.

12.3.3 Current Flow

The flow of electrons in electrical current is expressed in amperes, or amps. A force of one volt causing 6.25 x 1,018 electrons to flow past a point in a conductor with a resistance of one ohm equals one ampere of current.

12.4 Practical Applications: Measuring and Testing

Measuring and testing electricity should only be attempted by qualified persons with proper equipment because of the possibility of personal injury, fire, and damage to appliances and equipment. Safety guidelines include:

- Make sure electrical power to the appliance is disconnected while servicing.
- Do not energize the appliance if there is evidence of water leakage.
- Do not ground yourself while using measuring equipment. Use only one hand if possible.
- If possible, do not perform service alone.
- Assume that a circuit is live unless you are completely sure otherwise.
- Know emergency and first aid procedures.

12.4.1 Testing Equipment

Testing equipment should be used with caution and with thorough knowledge of testing and safety procedures.

12.4.1.1 Jumper Wires

Jumper wires are most often used in checking out switches. Extreme care must be used with jumper wires to avoid electrical shock. Jumper wires bypass a switch that is expected to be faulty. The circuit must be deactivated by opening a manual switch or by disconnecting electricity to the circuit. A jumper wire is connected across the terminals of the switch to be tested. If the circuit closes and the previously faulty valve or component works with the jumper wire, the problem is the switch. If the valve or component continues not to work with the jumper wire, the testing process must continue sequentially with each switch on the circuit. **Always remove jumper wires at the conclusion of the test. Leaving jumper wires in place to allow the appliance to operate may result in a hazardous condition.**

12.4.1.2 Multimeter

The multimeter, known also as a volt-ohm meter, is an essential tool for installing and servicing pellet hearth appliances. A wide selection of very adequate multimeters is available at electronics stores in the $80-150 range. Important features for pellet hearth appliance work include:

- Fuse protected meter
- Polarity plug

Other features that vary include dial or digital readings, number and convenience of functions, and range of sensitivity. These instruments can be used for a number of tasks, including measuring voltage (VAC and DC mV) and checking circuit continuity (resistance).

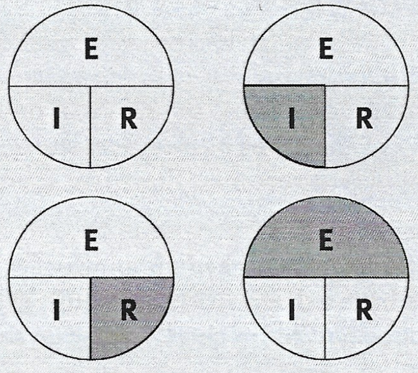
How it works: Ohm's law

The interrelationship of voltage, resistance, and current is stated in Ohm's law: the electromotive force (volts) in a circuit is equal to the intensity of the current (amps) times the resistance (ohms). Ohm's law can be expressed in a formula in which E represents electromotive force (volts), I is the intensity of current flow (amps), and R is stands for resistance (ohms):

$$E = I \times R$$

Ohm's law is useful in finding a missing value when the other two are known. The figure here is a simple graphic representation of the formula stated different ways.

Ohm's law guide



Cover the unknown value; the remaining two letters give the formula for finding the unknown value

12.4.2 Testing

Testing should be attempted only by qualified personnel with proper equipment and thorough knowledge of testing and safety procedures.

12.4.2.1 Measuring Voltage

The multimeter can be used to measure voltage when installing or servicing pellet appliances. The house outlet being used to power the appliance should be checked for proper voltage according to appliance manufacturer specifications.

Multimeter operation and safety

Do not use a multimeter without proper instruction or training and awareness of electrical hazards. Always follow multimeter manufacturer's instructions. General safety guidelines include:

- Follow the appliance or component manufacturer's testing and troubleshooting procedures.
- Protect yourself from direct contact with voltages above 60 volts DC or 25 volts AC as they may constitute a serious shock hazard.
- Always turn off power to a circuit (or assembly) under test before cutting, unsoldering, or breaking the current path.
- Always disconnect the live (normally red) test lead before disconnecting the common (normally black) test lead from a circuit.
- Higher voltages and currents require greater awareness of physical safety hazards. When it's possible to make clip-on connections to the circuit under test, make the connections without power applied:
  1. Turn off power to the circuit under test
  2. Set the meter to the appropriate function and range
  3. Connect the test leads to the meter, then to the circuit being tested
  4. Reapply power
  5. Record measurement or adjust the equipment as needed
  6. Turn off power and disconnect test leads
- If any of the following indications occur during testing, turn off the power source to the circuit being tested:
  - Arcing
  - Flame
  - Smoke
  - Extreme heat
  - Burning smell
  - Discoloration or melting of components.

  Do not attempt to remove the meter leads from the circuit under test. The leads, meter, or the circuit under test may have degraded to the point that they no longer provide protection from the voltage and current applies.
- **In the event of electrical shock, ALWAYS bring the victim to the emergency room for evaluation, regardless of apparent recovery. Electrical shock can cause unstable heart rhythm that may require medical attention.41**

Voltage is checked on some pellet appliances at the control board, on others at individual components, while still others have a diagnostic mode built into the unit to indicate proper function without the need to check for voltage. It may not be possible to check voltage on some appliances that use a microprocessor to supply variable voltage to motors and fans.

12.4.2.2 Measuring Polarity and Ground

The house outlet should be checked for proper polarity and ground.

12.4.2.3 Continuity Test

A continuity test checks whether a pathway exists through a particular component. THE COMPONENT MUST BE COMPLETELY DISCONNECTED FROM A POWER SOURCE. For an accurate test, it is important that good contact be made with the part being tested. Probes should touch bare wire or metal, not insulation, paint, corrosion, or dirt. Use alligator clips when possible since they give firmer contact and free your hands. Twist and tug on wires to help discover a weak connection.

If testing for an open circuit, clip a jumper wire to component leads **WITH POWER DISCONNECTED. Also disconnect one side of the device being tested** (to avoid "backdoor sneak," false readings of the current supplied by the multimeter). Multimeter should be set to read ohms (R x 1). Touch or clip multimeter probes to the circuit terminals being tested. Zero ohms reading means wire or component continuity is good; high ohms indicate an open circuit that must be examined further.

12.4.2.4 Resistance Testing

Improper resistance can indicate a faulty component. For a motor, such as the auger motor or blower motors, the proper resistance must be known. Such information should be available from manufacturers; note or ask whether the temperature of the component affects the resistance reading. A zero ohms reading WITH THE POWER DISCONNECTED indicates a short circuit in the component.

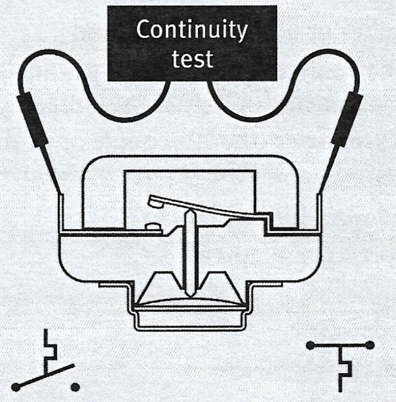
Snap switches can be checked with a multimeter set to measure ohms WITH POWER DISCONNECTED. The type of switch must be identified:

- Normally open at room temperature (for example, blower control that closes and comes on at specified temperature)
- Normally closed unless heated beyond its specified limit (for example, high limit switch, hopper heat sensor).

Test cold, hot, return to cold.

Similarly, it must be known whether a pressure sensitive switch is normally open or closed in order to check resistance. It must also be known whether negative or positive pressure must be applied to the switch for testing.

Testing limit switch

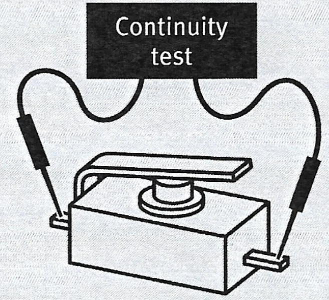


N.O.
(normally open)
No continuity until temperature rise

N.C.
(normally closed)
Continuity until temperature rise

©CSS

Testing lockout switch



N.O. (normally open)
- Plunger up - no continuity
- Plunger down - continuity

N.C. (normally closed)
- Plunger up - continuity
- Plunger down - no continuity

©CSS

Appendix A Tools and Instruments

To properly adjust, service, or troubleshoot gas appliances, the service technician must have the proper hand tools and test equipment. Tools are also are mark of professionalism. Industrial-looking tools specifically for the application and tools that the customer does not have impress the customer and help justify the cost of professional service.

A.1 Suggested Tools

- Straight screwdrivers – offset, stubby, small ⅛" blade for pilot adjustment; also stubby straight)
- Phillips screwdrivers – offset, stubby, #0, #1, #2
- Nut drivers – assortment including ¼", 5⁄16", 11⁄16"
- Torx drive set
- Square drive (Robertson head screw)
- Quick-wedge screwdrivers
- Open-end wrench set
- Adjustable end wrenches – 8" and 10"
- Pipe wrenches – 8"-14"
- Basic set of wrench
- Hex wrenches – T-handle 3⁄16" ball tip, Allen type 3⁄16"
- Flare wrench set
- Pliers – regular, needle nose, locking, slip joint, crimp, wire cutters, wire stripper
- Tubing Cutters – regular, mini
- Flaring tool
- Tube bender
- Numbered drill set (wire gauge)
- Drop cord/light
- Flashlight
- Drill
- Lighter wand
- Fire extinguisher
- Inspection mirror
- Reach tools – claw pickup, magnetic
- Mini-hacksaw
- Multi-pocket tool
- Pocket knife
- Pipe threader – ½", ¾"
- Thread cutting oil
- Pipe cutter
- Unibit or pipe reamer
- Pipe extractor – ½", ¾"
- Pipe vice

All tools and test equipment should be properly stored and maintained.

A.2 Suggested Testing Equipment

- Digital multimeter – industrial grade, fuse protected (not calculator type)
- Gas pressure testing gauge – digital, slack tube, or magnehelic
- Air pressure gauge
- Electronic gas sniffer or leak detection fluid
- Carbon monoxide analyzer: combustion gas analyzer or CO detection attachment for digital multimeter
- Digital temperature meter (thermocouple or probe)
- Analog draft gauge
- Thermocouple adapter (or test block)
- Multimeter temperature adapter
- Circuit tester
- AC/DC current detector
- Smoke test matches
- Multimeter alligator clips
- Jumper leads – 10-14" long
- Stopwatch
- Electronic stud finder

A.3 Home Protection

- Drop cloth
- Rug runners (for protected walkway from door to work area)
- Shop vacuum
- Broom and dust pan
- Carpet sweeper
- Waterless hand cleaner
- Glass cleaner, metal polish, and towels

A.4 Miscellaneous

- Pipe joint compound – approved for propane gas
- Teflon tape – for natural gas fittings only
- Nail polish/paint stick
- Wire connectors/splicers
- Plastic electrical tape
- Fresh AA and AAA batteries for remote controls

Appendix B Understanding Higher and Lower Heating Value

$$\varepsilon = \frac{\text{Output}}{\text{Input}}$$

The difference between the two efficiency ratings comes from the details of the basic definition of efficiency in the formula as Heat Output divided by Heat Input.

The point of disagreement between HHV and LHV is the interpretation of Heat Input. The difference is whether potential heat from condensation of combustion-produced water vapor (known as latent heat of vaporization) is included in the total energy input.

HHV, used in North America, reflects the total energy produced by complete combustion of fuel.

LHV, used in Europe, calculates and subtracts the heat that would depend on condensation to be recovered.

Using (dividing by) a higher value for Heat Input in the formula for efficiency yields a lower efficiency value (HHV) and using (dividing by) a lower value for Heat Input yields a higher efficiency value (LHV), as demonstrated by the following examples.

The resulting efficiency numbers in the two methods are different, but they correlate consistently: the efficiency value calculated using HHV is about 93% of the identical efficiency calculated using LHV.

To convert HHV to LHV, multiply HHV by 1.07:
70% x 1.07 = 75% LHV.

To convert LHV to HHV, multiply LHV by 0.93:
75% (LHV) x .93 = 70% HHV efficiency.

Note: Larger differences are possible depending on different definitions of LHV used in various European test methods, which may also deduct the latent heat from fuel moisture content and/or the heat required to maintain flue gas temperatures from the energy input.

For better understanding of the key difference in the two methods, the energy associated with condensation of combustion-produced water vapor, we offer the following explanation of the calculation of the latent heat of water that is subtracted from HHV to yield LHV Heat Input.

Heat of Water Deduction

The calculation to subtract heat involving condensation of water vapor begins with the known amount of energy required to convert water from a liquid to a gaseous state (1030 BTUs per pound of water, known as Latent Heat of water). First, the amount of water produced by combustion is calculated with the knowledge that most wood contains about 6.5% hydrogen by weight (for our purposes, but in practice determined by sample testing), and 1 pound of hydrogen in the fuel produces 9 pounds of water. Therefore, burning one pound of dry pellets produces 0.065 x 9 = 0.585 pounds of $H2O$.

The next calculation is to determine the amount of energy required to convert this water from liquid to gaseous state. We multiply the latent heat of water times the pounds of water produced: 1030 x 0.585 = 602.5 BTUs. In addition, there is a loss of about 250 BTUs of heat required to maintain the combustion products above 160°F to prevent condensation.

Finally, we subtract the latent heat of water and the sensible heat required to maintain 160°F flue temperature required from the overall heat produced:

8,600 – 603 – 250 = 7,747
LHV Input= 7,747 BTU/dry lb.

In Europe, LHV measurement might also deduct for water that comes with the fuel as moisture content. For example, if the wood fuel has 20% MC, there would be an additional 0.20 lbs of water per dry lb of fuel so there would be 1,030 x 0.20 = 206 BTUs of latent heat loss per pound. It would also require another 8 BTUs to maintain the vapor at a high enough temperature that it will not condense back to liquid water (about 160°F). Subtracted from the dry LHV Input (7,747 – 206 – 8 = 7,533) the net LHV for this method is 7,533 BTU/dry lb.

Appendix C Operational Cost Calculation

You will need to know:

- The input rating of the appliance in BTUs per hour
- The local cost per unit of fuel gas (usually therms for natural gas; gallon or pound for propane)
- BTU values for therms and gallons or pounds.

The input rating information is included on the appliance label. The cost per therm of natural gas or per pound or gallon of propane should be available from the local gas or propane supplier. The conversion table at right gives the BTU values for the different gas measurements.

Gas measurement unit values

Natural gas		Propane	
Unit	**BTUs**	**Unit**	**BTUs**
Therm	100,000	Gallon	91,690
		Pound	21,591

$$\frac{\text{Appliance BTU input rating}}{\text{BTUs per unit (therm, gallon, pound)}}$$

For example, for a natural gas appliance with an input rating of 38,000 BTU/hr., we calculate:

$$\frac{38{,}000 \text{ (BTU/hr rating)}}{100{,}000 \text{ (BTU per therm)}} = .38 \text{ therms per hour}$$

or for a propane appliance with the same input rating of 38,000 BTU/hr. for propane sold by the gallon:

$$\frac{38{,}000 \text{ (BTU/hr rating)}}{91{,}690 \text{ (BTU per gallon)}} = .41 \text{ gallons per hour}$$

Formulas for Operational Cost Calculation

To calculate the gross fuel cost per hour (efficiency not considered) for operating a gas hearth appliance, we determine first the amount of fuel the appliance used in one hour (at high burn). We derive that figure by dividing the appliance BTU input rating by the BTU per unit (therm, gallon, or pound) from the Gas Measurement Values Table above:

We can easily calculate then the operational cost per hour by multiplying the usage (portion of therm, gallon, or pound) per hour by the cost per unit ($ per therm, gallon, or pound):

A. Usage per hour

B. Cost per unit X (therm, gallon, pound) ($ per therm, gallon, pound) =

C. Cost per hour

- **Example 1.** Natural gas appliance with BTU Input Rating of 40,000 BTUs per hour; local cost of natural gas $1.18 per therm:
  1. Determine per hour usage in therms: 40,000 ÷ 100,000 = .40 therms per hour
  2. Determine cost per hour: .40 x 1.18 = $0.47 per hour (47¢ per hour)
- **Example 2.** Propane gas appliance with BTU Input Rating of 25,000 BTUs per hour; cost of propane $1.81 per gallon:
  1. Determine per hour usage in gallons: 25,000 ÷ 91,690 = .27 gallons per hour
  2. Determine cost per hour: .27 x 1.81 = $0.49 (49¢ per hour)
- **Example 3.** The propane gas appliance in Example 2 has a standing pilot that you want to take into account. Standing pilot cost. (Use 1,000 BTU/hr. input and calculate as above).
  1. Determine per hour usage in gallons: 1,000 ÷ 91,690 = .01 gallons per hour
  2. Determine cost per hour: .01 x 1.81 = $0.02 (2¢ per hour)

It is not surprising that fire would be a central element in the phenomenon that has swept the country in recent years, known as the outdoor room. The view of a blazing fire brings enjoyment, comfort, and a sense of tradition to this new home area for celebrations and for relaxation with family and friends.

Both the tradition of firewood and the convenience of gas both attract many customers to a wide array of outdoor hearth products and designs. As with the indoor versions of these hearth systems, outdoor hearth products call for a proper level of knowledge and expertise in planning and installing fire safely in outdoor areas.

Appendix D Professional Etiquette

The key to customer satisfaction is providing value. A hearth appliance installer or service technician must "sell" the customer on their ability to give exceptional, professional service. Taking care of the little details makes all the difference in the world. In simple terms, look at your service through your customer's eyes, and provide the most professional service that you can.

Len Schleshinger, the former Chairman of the Harvard School of Business once said, "People don't care how much you know, until they know how much you care." Installers and service technicians are full of facts, figures, industry jargon and answers to most consumers' questions. However, the consumer needs to know that your number one desire is to take care of them quickly, efficiently, and professionally. You can list the deficiencies about their installation, but you must answer their biggest question(s): What does it mean to me? Why is it important for the customer? What difference does it make? The technician must realize that the customer does not understand the intricacies of proper installation and sound venting principles. Once you explain their true benefit, in a way the customer can grasp, the customer will begin to appreciate the value of your service. Tell them what needs to be done and why it is important to do it right.

The hearth industry is full of jargon such as insert, zero-clearance, liner, flue, draft and smoke chamber which can lead to confusion. In many cases, customers are too embarrassed to ask for an explanation; so they often move on to a competitor. Carefully and briefly explain terms to your customers making sure that the words you use are clear and understandable. Good communication skills are paramount to delivering exceptional customer service.

A telephone call to the customer can set the tone for the appointment. The customer will perceive the attitude of the person with whom they are speaking. Smile while speaking on the telephone. Return all calls promptly. This is a very simple courtesy to provide excellent customer service. A customer leaves you a message and all you need to do is call them back. An easy way to impress potential customers is to simply return those telephone calls in a timely manner.

Technology has made it so much easier to keep your customers informed. It is a good practice to call the customer when you are on the way or if you are going to be late. The better you communicate with your customer, the more enthused they will be with the service you provide.

Examine your business vehicle. Does it look professional? A clean, well lettered vehicle will put the customer at ease and helps to advertise your company. Aggressive or reckless driving and illegal maneuvers are a reflection of the business. You must be at the top of your game anytime you are driving a vehicle with the business name on it. Cutting off another driver, blowing through a red light, or acting in an unprofessional manner when driving is a reflection of your culture and business attitude.

If possible, do not park on the customer's driveway. Never park on their driveway if your vehicle leaks any fluids. As a general rule of thumb, if possible, park on the street in front of the customer's house.

Once you arrive at the customer's house, get out of your truck and go to the door immediately. Do not sit in your truck when parked at the customer's house. Be prepared and have your paperwork organized so you do not have to shuffle through it when you arrive. A customer knows the minute someone pulls in their driveway or up to their house. Many times, there is a child or a dog that is helps to notify the world that you have arrived. The longer you sit in the vehicle before coming to the door, the more agitated your customer may become.

Make sure your clothing is clean, remove any sunglasses or hats and leave them in your vehicle. Have your NFI photo ID or business card ready to present to the customer to assure them you are the person that they are expecting. Once you ring the doorbell, step back 2-3 feet away from the door. Do not crowd the front door. Leave some space between yourself and your customer.

The words we choose to use make up about 7% of our communication with others. Our tone of voice makes up about 38%. This means that 55% of communication is a result of body language. Smile, maintain good eye contact, carry yourself with an air of confidence but do not cross the line and display arrogance. Assure the customer you are there to help and that you are the person that can handle the job.

Before entering the customer's home, consider taking your shoes off or use slip-on booties. Use a clean drop cloth or some sort of floor protection if necessary. Regardless of the home's condition, treat it as if it were a palace.

Make sure you have all the right tools with you and they are in good shape. A paper clip may work to bypass a safety switch but a jumper wire will look much more professional. If the customer's tools are of better quality and in better shape than yours a customer may wonder why you are the one being paid to do the job.

When you enter the customer's home, the most important thing to do is to listen. Ask questions. Try to find out all the customer's concerns. What happens and when does it happen? Take notes to so you can address all the customer's concerns before you leave. Then give the customer a description of what you plan to do and how long it will likely take.

A digital camera, your cell phone, or tablet can time and date stamp a photograph as a quick easy way to document any pre-existing conditions or defects. Take photographs from all angles and make sure they are clear.

Do not assume you may use the customer's furniture, tools, or bathroom facilities. Always ask permission first. Pay attention to the children, yet make sure they are clear of your work area. You may have to explain your concern for their safety with their parents.

You must carefully educate the customer without talking down to them. Use clear, professional language without adding a lot of industry jargon while in a customer's home. Don't make derogatory remarks about co-workers, other homeowners or previous service companies. Never swear or use crude language. Speak and behave professionally at all times.

It is important to communicate your findings clearly to the homeowner when problems are discovered. Some technicians choose to follow up with a report, rather than talking to the customer while at their home. It is always best way to accompany your written reports with photos.

Before you leave, be sure to clean up the area where you have been working. Always leave the home cleaner than when you came in. Make sure the customer has your business card and your contact information before you leave. Shake their hand and thank them for their business.

The most successful companies talk to their customers about proper maintenance procedures. As you prepare to leave the home is the perfect time to set up an appointment for next years' service. You may also want to ask the homeowner if they can recommend you to family or friends. A personal recommendation from a satisfied customer is your best advertising.

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Glossary

Air Infiltration. Typically, the passing of air into the house through small cracks or gaps inherent to the structure. Affected by temperature difference between the inside and outside of the structure, and air pressure factors (e.g., wind, the operation of solid fuel appliances or electrical appliances such as fans).

Air Inlet. The designed port(s) of entry for combustion air in a controlled combustion, solid fuel burning appliance.

Air Inlet Control. The means by which the amount of air entering the air inlet is regulated. Also referred to as air control.

Air Supply. Broadly, the air that is supplied to the firebox of the woodburning appliance.

Air-to-fuel Ratio. The ratio of air and fuel, by weight, in a solid fuel appliance. It should be noted that 1 pound of dry air occupies a volume of 13.315 cubic feet at 70°F. Therefore, 35 pounds of air, the typical amount of air necessary to burn 1 pound of wood in a fireplace, occupies 466 cubic feet.

Aldehydes. Class of compounds with distinct pungent odor, produced during incomplete combustion of a fuel gas.

ANSI. American National Standards Institute. The coordinating organization for federated national standards system, consisting of 900 companies and 200 trade, technical, professional, labor, and consumer organizations.

Appliance. A solid fuel burning product.

Appliance Regulator. The appliance component, usually part of the combination valve that maintains constant gas pressure.

Appliance to Flue. Means of venting a solid fuel appliance (including fireplace inserts) into masonry fireplace chimneys; the stainless steel connector passes from the appliance to the first clay flue liner. Also referred to as direct connection.

Approved. Acceptable to the authority having jurisdiction.

Ash. Noncombustible solid byproduct of solid fuel combustion.

Authority Having Jurisdiction. The organization, office, or individual responsible for "approving" equipment, installation, or procedure.

Automatic Gas Control Valve (also Combination Valve)**.** Gas valve which combines control functions; usually consists of gas manual valve assembly; pilot safety shutoff system, diaphragm valve, gas pressure regulator, and valve operator.

Baffle. An obstructing device or partition in a solid fuel appliance, used to direct the flow of gases and heat.

Blower Door. A diagnostic tool used to measure the tightness of buildings. Consists of a calibrated fan for measuring airflow rate and a pressure-sensing device to determine house pressure levels.

Breaching. Refers to the chimney connector access (hole) in a masonry chimney. See Chimney Breaching.

BTU or British Thermal Unit. A measure of heat energy; the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at sea level.

Burn Rate. Combustion rate, usually expressed in pounds of fuel consumed per hour.

Butane. A colorless, odorless, nontoxic gas; not generally used in hearth appliances.

Bypass Damper. Term specifically referring to the movable plate in some catalytic wood burning appliances that in one position channels the flue gases through the catalytic combustor, and in the other position channels the smoke to "bypass", or not go through, the catalytic combustor. On some noncatalytic appliances, a movable plate that redirects and increases residence time of gases.

Can. Holder for catalytic combustor usually made of stainless steel.

Canning System. Device surrounding catalytic combustor, usually consisting of insulation mat and stainless steel can, or holder.

Cap. Also termination cap. Covering for factory-built chimney that minimizes effect of wind, and prevents entry of rain, snow, and debris.

Carbon Dioxide. CO2. Colorless, odorless noncombustible gas produced by the complete combustion of carbonaceous fuel; is nontoxic.

Carbon Monoxide. CO. Colorless, odorless, combustible, and toxic gas produced by the incomplete combustion of carbonaceous fuel.

Catalyst. A substance that increases the rate of a chemical reaction without being consumed in the process. In solid fuel use, usually the precious metals palladium and platinum. Applied to the washcoat of the catalytic combustor.

Catalytic Combustor. Device designed to increase combustion efficiency by lowering flue gas ignition temperatures. Consists of substrate, washcoat, catalysts, and canning system.

Cement Board. Cement and reinforcing fibers formed into a sheet, often used as a tile backing board. Used in the hearth industry for thermal resistance properties as floor protection.

Chase. A structure built around, and enclosing, portions of the chimney and in some cases, housing the appliance.

Chimney. A portion of the venting system, through which flue gases are vented to the outdoors and by which penetrated combustible surfaces are protected; a primarily vertical shaft enclosing at least one flue, the design of which results in a natural draft.

Chimney Breaching. A means of venting a solid fuel appliance into masonry fireplace chimneys; the chimney connector passes through the chimney wall to the inside of the flue liner by means of a thimble or approved passthrough device.

Chimney Capacity. Refers to the volume of flue gases the chimney is able to handle; is affected by draft.

Chimney Connector. The portion of the venting system between the appliance and the chimney. Commonly called "stovepipe."

Cleanout Door. Means for closing and sealing the opening provided for inspection and removal of creosote and other chimney deposits; should be well sealed against air infiltration.

Clearances. Minimum distance which must be maintained between a heat source such as an appliance or vent and combustibles surfaces.

Cold Junction. Non-heated end of the thermocouple/thermopile.

Combustible Material. Material made of or surfaced with wood, compressed paper, plant fibers, or other material that will ignite and burn, as applied to materials adjacent to or in contact with heat-producing appliances, chimney connectors, steam and hot water pipes and warm air ducts. Such material shall be considered as combustible even though flame-proofed, fire retardant treated, or plastered.

Combustibles. Material made of or surfaced with wood, compressed paper, plant fibers, plastics, or other material that will ignite and burn in the presence of flame and/or heat, whether flameproofed or not, or whether plastered or not.

Combustion. The process of burning, or oxidation accompanied by heat. When sufficiently rapid, also accompanied by light. Rapid oxidation of fuel gases accompanied by the production of heat, or heat and light. Requires proper amounts of fuel, oxygen, and heat.

Combustion Ratio. Required amount of air that must mix with 1 cubic foot of gas to have complete combustion.

Compression Station. Place where pressure of natural gas is increased before it continues farther along the pipeline.

Condensate. The liquid that separates from a gas (including flue gases) due to a reduction in temperature.

Controlled Combustion. Complete burning of fuel with a steady flame when fuel and air supplied at proper rate. Contrast with explosion.

Controlled Combustion Appliances. Solid fuel appliances with relatively tight seals. The amount of air entering the air inlet, thus the combustion rate in the firebox is operator controlled.

Convection. The transmission of heat by the circulation of a fluid (air or water), caused by differences in temperature (and therefore density).

Cookstove. A controlled combustion solid fuel appliance with at least one oven and a surface designed for cooking.

Cornice. Overhang of a pitched roof, usually consisting of a fascia board, a soffit and appropriate trim moldings.

Cricket. Peaked secondary roof section constructed on top of, and perpendicular to the primary roof to divert water. Also known as saddle.

Cripple Stud. Short studs placed between the header and a top plate or between a sill and sole plate.

Crown. Beveled or sloping surface that terminates a masonry chimney; seals the flue; provides drainage slope for rain and snow. Recommended that gap (with flexible sealer) be maintained between flue liner and crown and that crown extend at least 2 inches beyond exterior chimney wall. Referred to as chimney cap in IRC and ASTM C 1283.

Damper. Movable plate that directs the flow of gases and air in a solid fuel appliance or chimney connector. In fireplaces, a pivoted metal plate, set just above the firebox, primarily used to close off the chimney when not in use. Also a hinged device located at the top of the chimney, controlled by a cable that extends to the firebox.

Diaphragm. Part of pressure regulator that responds to changes in gas pressure to maintain constant outgoing pressure.

Diethanolamine Treatment. Chemical process of removing hydrogen sulfide and carbon dioxide from gas. Sweetening the gas.

Directional Hood. A part of the pilot burner that directs the flame against a control device and then out across the main burner.

Direct Spark Ignition. A type of electronic ignition system that ignites the gas directly at the main burner by means of a spark.

Direct Vent. Method of venting appliance whereby all air for combustion is derived directly from the outside atmosphere and all flue gases are discharged directly to the outside atmosphere.

Distillation. Separation of solids and liquids from gases by application of heat. Method of extracting LPG from wet natural gas.

Draft Hood. A device built into an appliance or made a part of the flue or vent connector from the appliance designed to (1) provide for the ready escape of flue gases in the event of no draft, back draft, or stoppage beyond the draft hood; (2) prevent a back draft from entering the appliance; and (3) neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance. Also known as draft diverter.

Drip. In gas piping, a tee device used to collect condensate from gases. Installed so that they can be serviced to remove condensate. Also known as drip leg.

Drywall (or Gypsum Wallboard (GWB), Sheet Rock, Plasterboard, Wall Board, or Gypsum). A manufactured panel made out of gypsum plaster and encased in a thin cardboard or other material.

Eaves. The horizontal exterior roof overhang.

Elbow. The portion of the connector or chimney that turns or offsets the direction of the chimney.

Electronic Sniffer. A device that emits a loud, piercing noise in the presence of very small amounts of certain gases. Used in gas supply line and appliance leak detection.

Ethane. A hydrocarbon compound found in natural gas.

Excess Air. Air in the firebox or firechamber of a solid fuel appliance that is not used in combustion reactions (and exhausts through the venting system).

Excess Flow Valve (EFV). A gas valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate.

Explosion. Rapid burning with an improper rate of air and fuel; not under control and with excessive pressure.

Fascia. The visible flat front board that caps the rafter tail ends. Roof drain gutters are attached to the fascia.

Factory-built Chimney. A chimney composed entirely of listed manufactured components, designed to be assembled as an entire system in accordance with the terms of the listing.

Factory-built Fireplace. Prefabricated metal fire chamber and its chimney, commonly called "zero clearance." Consists of listed manufactured components that are assembled in accordance with the terms of the listing to form the completed fireplace.

Fire Chamber. See "Firebox."

Fire Resistance Rating. The time a material will withstand, without igniting, flame and heat as specified by code and specific test conditions.

Firebox. That portion of the solid fuel appliance where the fuel is located and where primary combustion occurs.

Firebrick. Heat resistant brick used in fireboxes; withstands very high temperatures.

Fireplace. An enclosure, open in the front, for burning fuel. Solid fuel fireplaces may contain and vent gas log sets or fireplace inserts. Gas fireplaces are metal appliances open in the front and containing artificial log sets.

Fireplace Insert. Solid fuel appliance designed to be installed partially or fully in the fire chamber of a masonry fireplace, and that vents into the fireplace chimney by means of full relining or appliance to flue methods.

Firestop. A noncombustible barrier, often metal, placed to span the air space between the outer walls of chimneys and surrounding combustibles; serves to resist the spread of fire between floors of a structure.

Flame Impingement. The “striking” of flame against an object, such as “flame impingement on the catalytic combustor.”

Flame Rectification. Means to ensure gas shutoff in the absence of flame in electronic ignition systems. Alternating current applied to an electrode engulfed in the pilot or burner flame is rectified, or changed to direct current, to power a control module to maintain gas flow until the flame is extinguished.

Flammability Limits. Minimum and maximum amounts of fuel (expressed as a percentage) in an air and fuel mixture within which combustion can take place.

Flashing. Also know as roof jack. Device that covers a factory-built chimney roof penetration and that helps stabilize the chimney.

Floor Protection. Noncombustible material of specified size, thickness, material and conductivity placed under a solid fuel appliance; required to extend beyond the four sides of the appliance. Serves to protect combustible floor surfaces and framing. Differs from hearth.

Flue. The passageway in a chimney for conveying flue gases to the outside atmosphere.

Flue Collar. The part of the solid fuel appliance that accepts the chimney connector. The flue collar diameter or dimension is designed by the appliance manufacturer to adequately accommodate the flow of gases out of the appliance.

Flue Gases. All combustible and noncombustible gases (plus excess air) that exit the solid fuel appliance.

Flue Liner. That portion of the chimney that contains the flue gases; is separated from the interior of the masonry chimney wall by an air space. Term refers to materials used with masonry chimneys, including clay tile, stainless steel, and poured materials; also referred to as Liner and Tile.

Fractionating. Extraction of impurities and hydrocarbons from wet and natural gas.

Freestanding Gas Appliance. An appliance with gas burning log set that has the appearance of a solid fuel appliance that is placed away from walls in a dwelling.

Full Relining. A means of venting a solid fuel appliance (including fireplace inserts) into fireplace chimneys; the listed liner extends from the appliance out the top of the chimney and includes insulation and components in accordance with the terms of the listing. Also referred to as positive connection.

Furnace. A central heating appliance that supplies hot air, through ducts, to the house.

Gable. The end, upper, triangular area of a home, beneath the roof.

Gas Control Knob Assembly. Part of the gas control valve that is a multi-positioned and tapered valve designed to allow or shut off gas supply to the appliance. Also known as gas cock assembly.

Gas Logs. An open flame type appliance consisting of a burner and metal pan or base supporting simulated logs. May include various ember media.

Gas Vent. A factory-made, listed venting system designed to remove flue gases to the outside atmosphere. See direct vent and Type B vent.

Gravity Ducting. Movement of heated air by nonmechanical means. Rising warm air travels to heat register higher than heat source and flows back as it cools and falls.

Gravity Vent. Type of venting that uses the natural draft of a column of warm gases rising due to the pressure of surrounding cooler air.

Header. A beam placed horizontal above doors, windows or other openings to carry the weight of structural loads.

Hearth. The floor of the firebox, most commonly used in reference to fireplaces. More generally, the foundation upon which fires for aesthetic and heating purposes are built. Differs from floor protection.

Hearth Extension. Noncombustible floor protection in front of and to the sides of a fireplace hearth.

Heat Loss Calculation. Calculation to determine house BTU loss; factors include conduction through construction materials, air infiltration losses and the difference between actual or projected outside temperatures and desired temperature inside the house. Used for determining necessary heat output from the heating appliance.

Heat Output. The amount of usable heat produced by a heating appliance; expressed in BTU (for solid fuel and most conventional fuel appliances).

Heat Recovery Ventilator (HRV). Mechanical system that uses blowers and an air to air heat exchanger to replace indoor air with preheated outdoor air.

Heat Value. Amount of heat potential of one cubic foot of gas when burned. Also known as caloric value.

Higher Heating Value (HHV). The amount of heat released by a specific quantity of fuel after it is combusted and the products have returned to their precombustion temperature, which includes the latent heat of vaporization of water in the combustion products (the heat from combustion-produced water is recovered).

Hip Roof. A roof that rises by inclined planes from all four sides of a building.

Hot Air Plenum. Sheet metal chamber mounted to the furnace, into which hot air is directed, and to which ducts are attached for hot air distribution into the house.

Hot Junction. Joined, heated end of thermocouple/thermopile.

Hot Surface Igniter. Type of electronic ignition system in which a glow bar is heated by electrical means to a temperature of about 2,500°F to provide the heat to ignite main burner gas.

House Pressure Test. A process to determine the level of depressurization within a residential structure under different conditions, including during use of exhaust devices. Results used in the hearth industry to determine whether maximum depressurization levels exceed spillage resistance pressure of hearth systems.

Hybrid Woodstove. A solid fuel appliance with dedicated air passages for the combustor, but also with separated dedicated air passages for secondary air combustion (as in non-catalytic stoves). Designated by EPA as a catalytic woodstove.

Ignition Temperature. The lowest temperature at which combustion occurs. Varies widely with reference to the variety of flammable gases spontaneously combusting in a solid fuel appliance.

Increaser. Chimney connector component that permits the transition from smaller to larger connector, thimble, liner, or chimney.

Infrared Radiation. Waves of light energy, beyond the visible part of the spectrum, that transfer heat energy and are converted to sensible heat when they strike a solid object.

Intermittent Ignition System. Means of lighting the pilot or main burner without the use of a standing pilot, by electronic spark or hot surface ignition. Also known as electronic ignition device.

International Fuel Gas Code. A standard for the installation of gas appliances, piping, and venting.

Ignition Systems. Devices that ignite the pilot burner and /or the main burner assembly.

Ignition Temperature. The temperature at which combustion of a substance begins.

Incomplete Combustion. Improper air/fuel mixture or inadequate temperatures resulting in less than complete burning of fuel. May produce aldehydes and/or carbon monoxide.

Joint Compounds. Non-hardening materials used on pipe threads to insure a proper seal.

Joist. Parallel framing member installed horizontally to support floor and ceiling loads.

Labeled. Equipment or material identified as having undergone approved inspection and compliance manufacturing and performance procedures.

Latent Heat of Water. The quantity of heat released (or absorbed) by a substance undergoing a change of state, such as ice changing to water or water to steam.

Lath. A building material of narrow wood, metal, gypsum, or insulating board that is fastened to the frame of a building to act as a base for plaster, shingles, or tiles.

Leakage Testing. Procedure to ensure that there is no uncontrolled flow of fuel gas in the gas piping system and/or the appliance.

Lifting Flames. An unstable burner condition in which flames rise above or blow off the burner port.

Limit Switch. Bimetallic device set to react to excessive temperature by causing gas flow to be cut off.

Lintel. A horizontal structural member that supports the load over an opening such as a door or window.

Liquefied Petroleum Gas (LPG). Colorless, odorless, and non-toxic gas separated from wet natural gas, light crude oil, and oil refinery gases. Composed predominantly of following hydrocarbons or mixtures thereof: propane, propylene, normal butane or isobutane and butylenes.

Listed. Equipment or materials tested to required standards by a testing organization and usually included in a list published by a model code authority that indicates that the equipment meets applicable inspection and testing procedure standards. Assures suitability for use in a specified manner when equipment installed in accordance with the manufacturer's installation instructions.

Load-Bearing Wall. A wall that supports structural weight above it. It supports overlapped or butted ceiling or floor joists running above it.

Lower Heating Value (LHV). The amount of heat released by a specific quantity of fuel after it is combusted and returned to a temperature above the condensation point of water vapor, which assumes that the latent heat of vaporization of combustion-produced water is not recovered.

Main Gas Burner. Device for the final conveyance of gas or a mixture of gas and air to the combustion zone. Consists of burner orifice, air shutter, mixer, and burner head.

Manifold. The conduit of an appliance that supplies gas to the individual burners.

Manifold Pressure. Gas pressure between the gas control valve and the burner orifice.

Manometer. Instrument used for measuring the pressure of gases.

Manufacturer's Installation Instructions. Instructions and recommendations for proper assembly, adjustment, and installation of listed equipment.

Masonry Chimney. A field-constructed chimney of solid masonry units, including brick, stone, listed masonry material, usually lined with fire clay flue liners. Proper construction covered in sources such as NFPA 211, Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances and International Residential Code (IRC). Chimney constructed onsite of masonry and clay materials; construction requirements specified by code. Also refers to existing masonry chimneys of various construction.

Methane. Main constituent of natural gas. Chemical formula CH4.

Millivolt (mv). Unit of electromotive force equal to one one-thousandth of a volt.

Mobile Home Appliance. Solid fuel appliance specifically designed to meet HUD standards for installation into mobile homes. Includes outside combustion air, floor mountings, substantially reduced clearances, and designated venting systems.

Moisture Content. The percentage of the fuel's weight that is water in comparison to the total weight of the water and wood in the wet method; in comparison to the weight of the oven dried fuel in the dry basis.

Multimeter. A device consisting of one or more meters used to measure two or more electrical quantities in an electrical circuit, such as voltage, resistance, and current.

Mixer. Component of a main burner where gas mixes with air. Consists of mixer face, mixer head, and mixing tube (venturi).

National Fuel Gas Code (ANSI Z23.1, NFPA 54). A standard for the installation of gas appliances, piping, and venting.

Natural Gas. Colorless, highly flammable gas found in porous geologic formations beneath the earth's surface. Consists mainly of methane.

Non Load-Bearing Wall. A wall that supports no load other than its own weight.

Noncombustible. A material that, in the form it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Odorant. Material added to natural gas or propane in small concentrations to impart a detectably distinct odor. Usually mercaptans.

Orifice. The opening in a cap, spud, or other device whereby the flow of gas is limited and/or controlled and through which the gas is discharged to either a pilot burner or main burner.

Orifice Spud. A removable plug or cap containing an orifice.

Oven Dry Wood. Wood dried at 217°F to a constant weight; defined as having "zero moisture content."

Opacity. Thickness of smoke. An indicator of combustion efficiency.

Parapet. A low protective wall along the edge of a roof.

Particulate Matter. Tiny pieces of condensable hydrocarbons in solid or liquid form. The basis of solid fuel emissions regulations of the Environmental Protection Agency.

Partition. The masonry wall that must separate flue liners in a masonry chimney. Also referred to as Wythe.

Pascal (Pa). The metric unit of measurement for pressures. One Pa equals 0.004 inches of water column (WC).

Plumb. Exactly vertical (perpendicular to a level horizontal surface).

Piezo Starter. A device that delivers an igniting spark by means of pressure on a crystal.

Pilot. A small flame used to ignite the gas at the main burner. May be standing (constantly burning) or intermittent (on and during demand for heat).

Pilot Safety Shutoff System. A component of the pilot or the gas control valve that allows or shuts off gas flow on the basis of the presence or absence of flame. Consists of a u-shaped electromagnet (see solenoid), gas shutoff disc, tension spring, keeper plate, thermocouple/thermopile connection, and a reset button. Also known as millivolt system.

Pressure Adjustment Screw. Part of a pressure regulator located directly under a cap screw on top of the regulator. Means of adjusting gas pressure on some regulators. Note: some pressure regulators are not subject to adjustment. Check manufacturer's instructions.

Pressure Regulator. A device for controlling and maintaining a uniform outlet gas pressure. Service regulators reduce high street pressure of natural gas or reduce propane storage tank pressure. Appliance regulators, usually part of the combination valve, reduce and maintain constant pressure to be used in an appliance.

Pressure Drop Test. Method of checking for leaks in the gas supply line prior to installation of appliances.

Primary Air. Combustion air directed to the firebox where the fuel is located; supports all stages of combustion.

Propane. aka Liquid Petroleum, LP or LPG Colorless, odorless, non-toxic, containing more heat value than natural gas.

PSI. Pounds of pressure per square inch.

Pyrolysis. Chemical alteration of wood, coal, or other combustible materials as a result of the application of heat. Stage of wood combustion during which wood molecules decompose into wood oil vapors and gases.

Rafter. A sloped structural member that extends from the ridge or hip of a roof to the eave, designed to support the roof deck and its associated loads.

Reducer. Also known as decreaser. Chimney connector component that permits the transition from a larger to smaller diameter chimney connector, thimble, liner or chimney. Not normally recommended because of potential smoke spillage and poor appliance performance. May violate code and/or manufacturer's instructions.

Refractory. Nonmetallic materials with chemical and physical properties that make them applicable for structures or as components of systems that are exposed to environments above 1,000°F.

Refractory Mortar. High temperature masonry mortar used primarily to join flue liners. Required by NFPA as medium duty, nonwatersoluble calcium aluminate refractory cement mixture, or its equivalent.

Residence Time. The amount of time the subject matter remains in the zone of reference, as in the residence time of gases in the fire chamber.

Ridge board. The board placed on the ridge of the roof onto which the upper ends of other rafters are fastened.

Roof Bracing Kit. Apparatus attached to the factory-built chimney above the roof that has braces, or legs, that attach to the roof to stabilize the chimney. Required by manufacturers for chimneys above a specified height above the roof.

Roof Sheathing or Sheeting. The wood panels or sheet material fastened to the roof rafters or trusses on which the shingle or other roof covering is laid.

Safety Shutoff. A system, usually powered by a thermocouple/thermopile or by an electronic control module, designed to shut off the gas supply to the pilot and/or main burner if the pilot or main burner flame is lost unexpectedly.

Secondary Air. Combustion air directed downstream of the primary combustion zone (but still in the appliance) to support the combustion of remaining combustible gases; does not directly influence the rate of primary combustion.

Sediment Trap. In gas piping, a tee device to intercept or hold solid foreign particles to prevent them from blocking valves or orifices. If not part of an appliance, must be installed as close to appliance inlet as possible.

Shake. A wood roofing material, normally cedar or redwood.

Siding. The finished exterior covering of the outside walls of a frame building.

Slab on Grade. A type of foundation with a concrete floor which is placed directly on the soil. The edge of the slab is usually thicker and acts as the footing for the walls.

Smoke. The visible portion of flue gases composed of solid, liquid, and gaseous products of combustion. Commonly used to refer to all exhaust from solid fuel burning.

Smoke Chamber. The transition zone between a fireplace throat and fireplace chimney, extending from the damper or throat to the base of the first flue.

Smoke Shelf. The ledge directly behind the throat of the fireplace, at the base of the smoke chamber.

Soffit. The underside board of eaves. Soffits are often vented to allow air flow through rafters into the attic.

Solenoid. Coil of wire that pulls an iron core within it magnetically when electricity flows through it. In use, known as electromagnet.

Solid Fuel. Wood, coal, and other similar organic materials in various forms (e.g., chunk wood, pressed logs, wood pellets, wood chips, paper, processed coal, coke, peat, charcoal).

Soot. Soft, black or brown velvety deposit of carbon particles inside appliances, chimneys, and connectors.

Sour Gas. Gas containing amounts of sulfur that prevent its use as a fuel unless purified.

Spark Arrester. A noncombustible screen installed between the top of the chimney and the underside of the chimney cap; prevents the escape of sparks and burning materials from the chimney.

Specific Gravity. The weight of one substance compared to the weight of another substance, both of equal volume.

Spillage. Condition of flue gases failing to exit the venting system properly and instead flowing out into the dwelling. Condition calls for immediate examination of appliance and venting system and corrective action.

Spillage Test. Method of detecting spillage. Flame or smoke applied at draft hood being blown out (away from draft hood) indicates spillage problem that should be remedied without delay.

Steel Lined Fireplace. Masonry fireplace with prefabricated metal firebox that has all the components of traditional fireplaces; may have double walls to provide circulating air passage behind the fire chamber.

Storm Collar. Metal plate or collar fastened and sealed with high temperature sealant around the chimney just above the roof flashing. Prevents water from entering the space between the chimney and the roof flashing.

Stud. A 2x4 or 2x6 vertical framing member used to construct walls and partitions.

Span. The clear distance that a framing member carries a load without support between structural supports.

Substrate. Catalytic combustor component that carries washcoat and catalyst. Must be inert, stable, porous material providing large surface area. Almost exclusively ceramic in solid fuel combustors.

Sweet Gas. Gas in its natural state containing such small amounts of sulfur that it can be used without purification processes.

TailOut. End of the burning process in woodburning appliances.

Tee. Chimney connector or factory-built chimney component that provides a 90° turn in the venting system; has a removable plate at the bottom for inspection and chimney cleaning convenience.

Temperature Differential. The difference in temperature between two areas, such as inside and outside the chimney or house. (Example if it is 90°F outside the house and 70°F inside the house, the temperature differential is 20°F.)

Termination. Components at the top of the chimney.

Therm. Unit of heating value equivalent to 100,000 BTUs.

Thermocouple. A device consisting of two pieces of dissimilar metals joined together at one end (hot junction). When the hot junction is heated, the thermocouple produces DC voltage across the other end. Used to power thermoelectric gas valves.

Thermopile. A number of thermocouples connected in series to produce a higher voltage than a single thermocouple.

Thimble. Generally, a clay or metal sleeve through which chimney connector passes to connect to a masonry chimney; construction depends on whether it is intended for passage through combustible or noncombustible material.

Throat. The narrow passage above the fire chamber of a fireplace, forward of the smoke shelf and below the smoke chamber; generally has a damper that must be opened before the fireplace is used, and may be closed when the fireplace is not in use.

Truss. A structure comprised of one or more triangular units designed to support a ceiling, roof, or floor.

Type B Gas Vent. Listed, factory-built, double wall metal pipe for venting appliances with draft hoods and other appliances listed for use with Type B Gas Vent.

Type B-W Gas Vent. A listed, factory-built, oval shaped, double wall metal pipe for venting (only) vented wall furnaces.

Unvented Room Heater. Category of unvented, self-contained, free standing, non-recessed (except as noted) fuel-gas burning appliance for furnishing warm air by gravity or fan without duct connection. Gas hearth appliances listed to ANSI Standard Z21.11.2 include Gas Fireplaces and Fireplace Inserts.

Valley. The "V" shaped area of a roof where two sloping roofs meet.

Valve Operator. Part of electronic automatic gas control valve that activates the flow of gas to the main burner. Also known as operator head.

Venting System. A continuous open passageway from the flue collar or draft hood of the appliance to the outside atmosphere for the purpose of removing flue gases.

Vent Orifice. Part of a pressure regulator, located in the chamber above the diaphragm. An opening that allows for the free flow of air in and out in the area above the diaphragm. Also provides for the escape of fuel gas in the event of a diaphragm rupture.

Vitreous Enamel. Material made by fusing powdered glass to a metal substrate with heat to produce a smooth, durable, decorative coating..

Washcoat. Material applied to the substrate of catalytic combustor to increase and maintain surface area. Chemically inert, usually a high surface area alumina.

Water Column (WC). Measurement in inches of pressure of gas. 28 inches WC equals one psi.

Weatherization. Work on a building exterior in order to reduce energy consumption for heating or cooling. Work involving adding insulation, installing storm windows and doors, caulking cracks and putting on weatherstripping.

Wet Gas. Unprocessed natural gas containing more than 20% of impurities and heavier hydrocarbons.

Wythe. The masonry wall or partition that must separate multiple flue liners in a masonry chimney. Also referred to as Partition.

Knowledge Statements

Purposes of the Index

The Knowledge Statements below are a comprehensive list of the knowledge needed to successfully plan hearth products. The list was developed through a formal process that included an industry wide survey of practitioners.

The knowledge statements from the blueprint for the exam and each exam question is linked to knowledge statements. The Exam Feedback from the exam now reports the knowledge statement numbers for each question missed. With that report, an examinee can better focus on and find subjects in the manual for reinforcement and further study.

The second purpose is to facilitate finding subject matter in the manual. The Index can help isolate a subject and make following it throughout the manual more efficient and convenient.

Using the Index

The use of the NFI Feedback Report and the Index of Knowledge Statements offers assistance in focusing study based on exam results. In some cases, the referenced areas will be still be broad, but the search process can be another exercise to strengthen familiarity with manual subjects and organization.

To use the Index for post exam reference, start by finding a numbered knowledge statement from the Exam Feedback Report in the Index.

For example Knowledge of chimney components. The list of manual sections is organized by chapter/section/subsections and includes an abbreviated section title. For example, 16.4.1.1 Firestops indicates Chapter 16, section 4.1.1 Installing Firestop Spacers. Section titles may be edited for index purposes.

You can use the chapter numbers on the left hand pages and the section numbers in the heading at the top of the right hand pages to locate the referenced information. The examinee can look through all the references or focus on study areas of concern.

I. Fundamental Knowledge

Category 1. Combustion

1. Knowledge of principles of combustion (CAT01K01)
2. Knowledge of consequences of incomplete combustion (CAT01K02)
   1.3 Incomplete Combustion
3. Knowledge of results and benefits of complete combustion (CAT01K03)
   1.2 Complete Combustion
4. Knowledge of air-to-fuel ratio (CAT01K04)
   1.2.2 Air
   1.2.3 Fuel

Category 2. Heat/Heat Protection

5. Knowledge of Heat Transfer Principles (i.e., conduction, radiation, convection) (CAT02K01)
   2.2 Heat Transfer Efficiency
   3.1 Factory Built Fireplaces
   3.6 Heat Delivery
6. Knowledge of heat distribution methods (e.g., mechanical [blower], ducting) (CAT02K02)
   3.1.2 Circulating Design
   3.2 Built-in, High Efficiency Fireplaces
7. Knowledge of required clearances to combustibles (CAT02K03)
   6.2 Clearances
8. Knowledge of required clearances to noncombustibles (e.g., noncombustible mantels, glass) (CAT02K04)
   6.2 Clearances
9. Knowledge of floor protection (CAT02K05)
   6.1.2 Floors
10. Knowledge of wall protection (CAT02K06)
   6.1.1 Framing, Walls, & Ceilings

Category 3. Safety Guidelines/Consequences of Action

11. Knowledge of consequences of improper installations (CAT03K01)
   6.1 Combustibles
   6.1.1 Framing, Walls and Ceilings
   6.1.2 Floors
   6.1.3 Heat Transfer
   6.2 Clearances
12. Knowledge of the causes and effects of carbon monoxide (CO) (CAT03K02)
   1.3.1 Carbon Monoxide
   7.7 Gas Safety

13. Knowledge of hazardous materials (CAT03K03)
    7.6 Hazardous Materials Safety
14. Knowledge of safety guidelines for installation (e.g., ladder safety, roof safety, lifting, weather) (CAT03K04)
    Chapter 7 Safety Guidelines

Category 4. Construction Fundamentals

15. Knowledge of basic home construction (e.g., framing techniques, roofing, thermal envelope) (CAT04K01)
    6.1.1 Framing, Walls & Ceilings
16. Knowledge of techniques for protecting client property in the work area (CAT04K02)
    Appendix D Professional Etiquette
17. Knowledge of construction factors that affect installation (e.g., wiring, obstructions, mobile home construction) (CAT04K03)
    8.3.4 Vent Route and Configuration
18. Knowledge of chase construction and weatherization (e.g., preventing air infiltration, installing insulation, firestopping) (CAT04K04)
    8.5 Chase Considerations

Installation Knowledge

Category 5. Regulation and Instructions

19. Knowledge of the relationship between codes, standards, and manufacturer's instructions (CAT05K01)
    Chapter 4 Codes & Standards for Hearth Appliances
    Chapter 10 Manufacturer's Instructions
20. Knowledge of jurisdictional roles and responsibilities (e.g., determining who has authority, applicable code and regulations, homeowners associations) (CAT05K02)
    4.3 Codes
    4.3.1 Local Codes
    4.3.2 Applicability and Retroactivity
    8.1.3 Regulations and Authority Having Jurisdiction
21. Knowledge of appliance installation requirements for mobile homes (CAT05K03)
    4.2.17 Manufactured/Mobile Home Requirements
22. Knowledge of techniques for interpreting codes and standards (CAT05K04)
23. Chapter 4 Codes & Standards
24. Knowledge of appliance installation code requirements, standards, regulations, and safety listings (CAT05K05)
    Chapter 4 Codes & Standards
25. Knowledge of techniques for interpreting manufacturers' installation instructions (CAT05K06)
    Chapter 10 Manufacturer's Instructions
26. Knowledge of appliance sizing recommendations and requirements (CAT05K09)
    6.3Appliance Installation Planning
    6.3.2.2 Planner's Recommendations

Category 6. Appliance Requirements

27. Knowledge of appliance types (CAT06K01)
    Chapter 3 Appliance Types
28. Knowledge of factors affecting appliance selection (e.g., house characteristics, fuel cost comparison, appliance purpose, climate) (CAT06K03)
    Chapter 3 Appliance Types
    5.1.4.1 Pressure Condition in the House
    Appendix C Formulas for Operational Cost Calculation
29. Knowledge of factors affecting the choice of an appliance location (CAT06K04)
    6.1 Combustibles
    6.2 Clearances
    6.3.2.1 Stove Location
30. Knowledge of appliance installation procedures (CAT06K05)
    Chapter 10 Manufacturer's Instructions
31. Knowledge of factory-built fireplace components as a system (CAT06K06)
    6.3.1 Factory Built Fireplaces
32. Knowledge of installation requirements for factory-built fireplaces (CAT06K07)
    6.3.1 Factory-built Fireplaces
    6.3.1.1 Clearances and Framing Dimensions
33. Knowledge of relationship of finish materials to fireplace placement (CAT06K08)
    6.3.3.1 Fireplace Dimensions and Condition
34. Knowledge of installation compatibility for aftermarket add-ons (CAT06K09)
    9.2.1.6 Other Appliance Components
35. Knowledge of existing masonry fireplace construction details and requirements (CAT06K10)
    8.6 Masonry Chimneys

36. Knowledge of installation requirements for fireplace inserts and hearth mounted stoves in masonry fireplaces (CAT06K11)
    3.4 Fireplace Inserts and Hearth Stoves
    6.3.3 Fireplace Inserts
37. Knowledge of installation requirements for fireplace inserts and hearth mounted stoves in factory-built fireplaces (CAT06K12)
    3.4 Fireplace Inserts and Hearth Stoves
    6.3.3 Fireplace Inserts
38. Knowledge of acceptable modifications to factory-built fireplace to install an insert (CAT06K13)
    6.3.3 Fireplace Inserts
39. Knowledge of basic electricity (CAT06K17)
    Chapter 12 Basic Electricity
40. Knowledge of purposes and uses of tools and gauges needed for appliance installation and service (CAT06K18)
    Appendix A Tools and Instruments
41. Knowledge of basic math in hearth installations (e.g., arithmetic, area and volume, properties of 2 and 3 dimensional objects) (CAT06K31)
    6.2.1 Corner Installations
    Chapter 10 Manufacturer's Instructions

Category 7. Draft and Ventilation Principles

42. Knowledge of draft principles (e.g., flow, volume, pressure) (CAT07K01)
    5.1 Principles of Draft and Flow
43. Knowledge of mechanical draft principles (CAT07K02)
    5.2.4.3 Mechanical Draft
44. Knowledge of the impact that flue gas temperature has on creosote formation (CAT07K03)
    5.1.4.1 Pressure Conditions in the House
45. Knowledge of resistance to flow in venting systems (e.g., angles/offsets, horizontal run) (CAT07K04)
    5.1.3.1 Factors Determining Flow
46. Knowledge of the effect of horizontal vent runs on appliance performance (CAT07K05)
    5.1.3.1 Factors Determining Flow
47. Knowledge of factors exterior to the house affecting draft (e.g., wind, vent height, relationship to other structures) (CAT07K06)
    5.1.4 Relationship of Natural Draft and Flow
48. Knowledge of house characteristics contributing to negative pressure problems (e.g., house tightness, house stack effect, exhaust devices) (CAT07K07)
    5.1.4 Relationship of Natural Draft and Flow
49. Knowledge of ventilation principles (e.g., draft, thermal effects, pressure) (CAT07K08)
    5.1.4.1 Pressure Conditions in the House
50. Knowledge of appliance effect on indoor air quality (e.g., spillage, moisture) (CAT07K09)
    5.1.4.1 Pressure Conditions in the House

Category 8. Venting Requirements

51. Knowledge of chimney/vent types (CAT08K02)
    8.1 General Venting Concerns
    8.2 Venting Components
52. Knowledge of liner systems (CAT08K03)
    8.8 Chimney Liner Systems
53. Knowledge of venting components (CAT08K04)
    8.2 Venting Components
54. Knowledge of chimney/vent connectors (CAT08K05)
    5.2 Chimney Connectors
    8.2 Venting Components
55. Knowledge of sizing requirements for chimney/venting systems (CAT08K06)
    8.3.1 Adequate Ventilation
    8.3.2 Vent Size
56. Knowledge of installation procedures for venting systems (CAT08K08)
    8.3.5 Venting Assembly
57. Knowledge of installation procedures for lining/relining chimneys (CAT08K09)
    8.8 Chimney Liner Systems
58. Knowledge of inspection and cleaning requirements for chimney/venting systems (CAT08K10)
    8.6.1 Masonry Chimney Condition
59. Knowledge of methods for venting appliances into existing solid-fuel chimneys (CAT08K11)
    8.9 Using Existing Chimneys
60. Knowledge of existing masonry fireplace construction details & requirements (CAT08K12)
    8.6 Masonry Chimneys
61. Knowledge of sidewall vent termination requirements (CAT08K13)
    Chapter 10 Manufacturer's Instructions

62. Knowledge of chimney/vent termination requirements (CAT08K14)
    8.3.6 Vent Termination
63. Knowledge of installation procedures for outside combustion air system (CAT08K16)
    10.6 Outdoor Combustion Air

Category 9. Post Installation Inspection and Service

64. Knowledge of operating procedures for appliances (CAT09K01)
    9.1 System Operation
65. Knowledge of causes and solutions to common appliance performance problems (CAT09K05)
    Chapter 11 Troubleshooting
66. Knowledge of troubleshooting procedures for testing appliances and venting systems (CAT09K06)
    Chapter 11 Troubleshooting
67. Knowledge of how to project a professional demeanor (e.g., communicate effectively, maintain professional appearance) (CAT09K09)
    Appendix D Professional Etiquette
68. Knowledge of appliance break-in procedures (CAT09K12)
    9.2 Paint Curing
    9.3 Appliance Break-in Procedures
    9.4 Recommended Start-up Service
69. Knowledge of electrical requirements for appliances (CAT09K15)
    Chapter 12 Basic Electricity
70. Knowledge of wiring diagrams (CAT09K16)
    Chapter 12 Basic Electricity

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